

HABITS AND ECONOMIC RELATIONS OF THE GUANO BIRDS OF PERU.

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INTRODUCTION.

In the course of an economic study of the guano and fishery industries undertaken for the Peruvian Government and carried on from December, 1906, to August, 1908, I enjoyed many opportunities for observing the habits and determining the commercial importance of birds frequenting the guano islands or their environments. On several occasions I was enabled to live in camp upon the islands during the season when they were by law closed to the general public, although on such favorable occasions it was never possible to give exclusive attention to studies of the birds.

After making the necessary reports with recommendations to the Government of Peru,¹ I returned to the United States with a body of uncompiled field notes, as well as with a considerable collection of specimens representing the fauna and flora of the coastal waters, and some specimens of the sea birds. The collections, excepting the birds and some miscellaneous specimens, have been reported upon by specialists in the several groups.² A general account of the guano

¹ Several papers in the Boletín del Ministerio de Fomento, published in Lima, 1907-1909. See also Regarding the future of the guano industry and the guano-producing birds of Peru. *Science*, N. S. vol. 28, No. 706, pp. 58-64. July 10, 1908.

² Howe, Marshall Avery: The marine algae of Peru, *Mem. Torrey Bot. Club*, vol. 15, pp. 1-185, 66 plates and 44 text figures. New York, Sept. 19, 1914.

Clark, Hubert Lyman: The echinoderms of Peru. *Bull. Mus. Comp. Zool.*, at Harvard College, vol. 3, pp. 1-358, 14 pls. Cambridge, Mass., Oct., 1910.

Dall, William Healy: Report on a collection of shells from Peru, with a summary of the littoral marine mollusca of the Peruvian Zoological Province. *Proc. U. S. Nat. Mus.*, vol. 37, pp. 147-294, with pls. 20-28. Washington, Nov. 24, 1909.

Pillsbry, Henry A.: Report on barnacles of Peru, collected by Dr. R. E. Coker and others. *Proc. U. S. Nat. Mus.*, vol. 37, pp. 63-74, with pls. 16-19. Washington, Oct. 18, 1909.

Richardson, Harriet: Report on isopods from Peru, collected by Dr. R. E. Coker. *Proc. U. S. Nat. Mus.*, vol. 38, pp. 79-85. Washington, May 3, 1910.

Walker, Alfred O.: Marine amphipods from Peru. *Proc. U. S. Nat. Mus.*, vol. 38, pp. 621-622. Washington, Oct. 18, 1910.

Weckel, Ada L.: Fresh-water amphipods from Peru. *Proc. U. S. Nat. Mus.*, vol. 38, pp. 623-624. Washington. Oct. 18, 1910.

Rathbun, Mary J.: The stalk-eyed crustacea of Peru and the adjacent coast. *Proc. U. S. Nat. Mus.*, vol. 38, pp. 531-620, with pls. 36-56. Washington, Oct. 20, 1910.

Evermann, Barton Warren, and Lewis Radcliffe: The fishes of the west coast of Peru and the Tittleca Basin. *U. S. Nat. Mus. Bull.* 95, pp. 3-157, with pls. 1-14. Washington, 1917.

and fishery industries appeared in the Proceedings of the Fourth International Congress meeting in Washington in 1908.¹ Various circumstances unnecessary to be detailed in this place combined to delay, first, the compilation of the observations relating to the habits of the birds, and, second, the publication of the manuscript after it was completed. During the past few years other investigators have studied the guano industry, but, so far as the writer is aware, no report has been issued to cover the ground of the present paper.² Its publication even at this time seems therefore desirable.

It does not seem inappropriate to indicate briefly, or at least to suggest, some of the conditions under which the studies were pursued, for, had more favorable circumstances prevailed, investigations covering a period of like duration might have been productive of more extensive and valuable results.

Travel was sometimes accomplished by taking a steamer from one port to another, whence small sailing skiffs were used to visit islands that were 10 to 50 miles from port and upon which temporary camps could be established if desired. At other times trips of 100 to 500 miles were made in a balandra, or small cargo sloop. In a few instances travel could most conveniently be made by pack over the desert.

As one may have inferred, the studies were primarily economic and directed at two related industries.³ In such a case the primary needs could be met only by securing accurate knowledge of the natural forms upon which the industries are based and recording the methods of operation as well as the precise conditions under which they were conducted. With only unskilled assistance available, it was necessary for the investigator to devote much time personally to the collection and preservation of specimens, to the inevitable routine of record keeping, and to the preparation of reports describing the existing commercial operations.

It will be understood that the conditions both of work and of travel were not favorable to the preservation of so many skins of birds as it would have been desirable to save. I am glad, however, to acknowledge the cordial aid rendered by Mr. Robert Gunner, of Callao, who, having started with me as interpreter, acquired some facility in the preparation of bird skins and in other services. In all, about 80 skins were saved and 30 lots of eggs. With the permission of the Peruvian Government, and by its direction, this small col-

¹ Coker, R. E.: The fisheries and the guano industry of Peru. Bulletin of the Bureau of Fisheries for 1908, vol. 28, Washington, pp. 333-365, pls. 12-17, 1910.

² Allusion must be made, however, to two interesting papers by Prof. Henry O. Forbes, which will be cited and quoted in a proper connection on a later page.

³ Peruvian guano is indirectly but obviously a product of fish. The birds in this case fulfil a function comparable to that of the American factories that convert fish into fertilizer. The operation of the birds may in some respects be relatively wasteful, but the product yielded by them has the virtue of being in a form more readily available to the growing crops.

lection was divided between the National School of Agriculture of Peru and the United States National Museum.

The specimens transmitted to the National Museum were identified by Dr. Charles W. Richmond, to whom grateful acknowledgment is made. All specimens were provisionally identified in the field, with the aid principally of Taczanowski's invaluable *Ornithologie du Pérou*.¹ It was found that few errors had been made in field identifications and that these did not apply to any of the important species. Accordingly, the observational data is of correct application to the several species treated.

I can not fail to express my strong sense of indebtedness to Señor Don Carlos Larrabure y Correa, then Director de Fomento, who, with sympathy, wisdom, and energy, facilitated my investigations in every way possible. Mr. Edmundo de Habich, at that time chief of the division of agriculture, extended me many courtesies and valuable assistance. To Capt. Chase, manager of the Callao house of Messrs. W. R. Grace & Co., and to Mr. H. H. Bunting, chemist of the Peruvian Corporation, I was sensibly indebted for counsel and suggestions. Finally, I may with full propriety acknowledge the invaluable encouragement derived from a knowledge of the direct and personal interest maintained throughout the investigations by Señor Don Manuel Pardo, at that time President of the Republic of Peru, and by Señor Don Augusto B. Leguia, then minister of the treasury and subsequently President, both of whom gave effect to some of the recommendations offered in course of the study.

The following pages deal more particularly with the habits and significance of birds that were observed to possess economic importance, but they comprise also some account of other species which are associated with the useful birds as enemies or as competitors, and such additional data as are essential for an understanding of the conditions of life of the birds and their economic significance.

GENERAL FEATURES OF THE COAST.

From Paita, at 5° south latitude, to the southernmost limits of present Peruvian territory, a distance corresponding to that between New York and Cuba, or about 1,300 miles, the coast of Peru and the waters bathing its shores are characterized by conditions of remarkable uniformity. Striking physical features, and significant as affecting both aquatic and avian fauna, are the bold and rocky shores, the absence of large islands, the moderate but almost invariable southwest trade winds, the low humidity and the relatively and unvaryingly cold sea water.

¹ Taczanowski, Ladislas. *Ornithologie du Pérou*, vols. 1-3, and a volume of tables (key and index). Rennes. 1884-1886.

As is well known, the continental shelf bordering the coast of Peru is very narrow and the sea bottom declines from the shore so precipitately as to leave few bays or harbors and no really large islands. The cold Humboldt current, with its steadily and visibly flowing waters, is thus brought so close to the mainland shore as to preclude the occurrence of warm seas or the development of typically "tropical" conditions.

The temperatures of the surface waters have been treated in a separate paper.¹ It may be sufficient here to say that surface temperatures as low as 17° C. (63° F.) were noted in the bay of Paita (5° S.) in midsummer, while a temperature of 16° prevailed at Mollendo (17° S.) in midwinter. Excluding observations in protected waters, the observed range of temperature in any locality did not exceed 3.4° C. and was usually 1° to 1.5° C. The air temperatures exhibit some variation, but, about the islands, at least, they are so generally governed by the water as to make the seasonal changes relatively small. That such uniformity of temperature conditions may have a marked influence upon the breeding habits and breeding seasons of the birds is to be inferred, and in the following pages, in reference to several species of birds, there will be noted a tendency to prolong the breeding season, if not to extend it over the entire year.

Since breezes from a cool sea must pass over lands that are warmed under a tropical sun, no opportunity for precipitation occurs and neither rainy seasons nor occasional rains may prevail. It is true that in the very northern portion of Peru heavy rains may occur at intervals of years, and at no great distance from the coast, and that the mainland coast generally becomes sufficiently cooled in winter to suffer a settled condition of fog and mist, or *garua*; but the several islands a little offshore are, absolutely or practically, free from rainfall, and conditions of atmospheric moisture sufficient to permit of the growth of ordinary vegetation can be found only upon the high peaks which are wrapped with clouds. The most interesting and economically significant consequence of the arid climate is that the nitrogen of the guano deposited by the birds can not become converted into ammonia to be lost by evaporation, but is permanently preserved in a form readily available for the purposes of agriculture. The absence of rains and storms must have no little effect, too, upon the abundance of available food and upon the successful propagation of the birds.

Notwithstanding the general correctness of the preceding statements, a distinct difference may be noted in the atmospheric conditions prevailing over the northern islands. Nearer the equator and the upper limit of the Humboldt current the sea breeze comes some-

¹ Coker, R. E. Ocean temperatures off the coast of Peru. *The Geographical Review*, vol. 5, New York, February, 1918, pp. 127-135.

what warmer and more moisture-laden, and it is undoubtedly true that at rare intervals the northern current has reached at least as far south as the Lobos Islands. Light rains are not unknown at Lobos de Tierra (6.5° south), and this doubtless accounts for the presence of certain very small patches of vegetation and for the inferior quality of the guano.

With conditions so uniform along the coast, it is evident that at one time or another birds may have occupied rookeries at thousands of different places on mainland or island, and breeding places, even of the distant past, would be marked by the accumulation of guano. Hundreds of places have, in fact, been the seat of commercial operations in the extraction of guano. Chief in historical importance are the Chincha and Ballestas Islands, the islands of Guañape and Macabi, and the larger Lobos Islands, de Afuera and de Tierra. Pabellon de Pica was an important point at one time, but it has passed from the jurisdiction of Peru and was not, therefore, included in the field of my observations. Many places of secondary importance might be mentioned, such as the *Islas Santas*, *Palominos*, *Fronton*, *Asia*, *Santa Rosas*, *Vieja*, and *Cerro Azul*.

The writer visited all of the islands of importance except the *Islas Santas*, northward from *Chimbote*. A list of these points, with the approximate latitudes, is given in an appendix. There were scarcely any noteworthy breeding places on the mainland at the time of my visit, so that the scenes of observation were principally upon the islands.

CHARACTER OF THE PERUVIAN ISLANDS.¹

None of the islands are very large or far removed from the coast. One of the nearest islets (*Isla Lobería*, near *Cerro Azul*) is so close to the main shore as to be conveniently reached by an aerial trolley, while most of the islands are not more than 10 or 12 miles removed. The single group at all remote is the *Lobos de Afuera*, which is about 33 nautical miles from the nearest point of mainland. The largest island is that of *Lobos de Tierra*, with its length of nearly 6 miles and a width varying from one-sixth of a mile to 2 miles. The *Lobos de Afuera* Islands combined are slightly smaller, while each of the two larger *Chincha* Islands will not average a half-mile in diameter. The south (and smallest) island of the *Chincha* group, and recently the most important, has an extent of less than 30 acres, the greater part of which was covered by the nests of birds. The islands of *Ballestas*, a sister group of the *Chinchas*, and, like it, composed of three principal units, are approximately equal to the smallest of the *Chinchas*. They are bolder and higher and must be gained by climbing from

¹ For mention of practically every island and detailed description of certain features of the coast of Peru, see Rosendo Melo's admirable "Derrotero de la Costa del Perú," pp. XLVIII, 302.

the water, being without beaches except at the bases of unscalable cliffs. These islands of Ballestas are from 100 to 300 feet in height.

All of the islands are more or less bold, rocky, and barren. The rocky nature of the ground and the general presence of too strongly concentrated fertilizer, as well as the want of atmospheric moisture, would seem to preclude the possibility of plant growth. At any rate, vegetation of any kind is entirely absent, except where the higher points reach such an altitude (about 1,200 feet) as to derive moisture from the clouds; the higher peaks may, therefore, support luxuriant but entirely isolated gardens of vegetation. This occurs only on such lofty islands as San Gallan, La Isla Vieja, and San Lorenzo.

Naturally, on such barren islands, when the ultimate source of food is in the sea, the fauna is very restricted. Besides the birds and sea-lions, we find only parasitic insects, and their enemies, the spiders, scorpions, lizards, and bats;¹ except that, on the verdure-clad peaks just mentioned, colonies of land snails have in some way been introduced, perhaps by the condors which visit back and forth from mainland to island. Escaped cats live freely on Lobos de Afuera. I observed an otter in the water near the beach of San Gallan, and also captured a specimen of cricket on the beach of the same island.²

There are certain islands for which the birds show a predilection, and some of these appear to have been favored breeding places for centuries. Particular islands appeal to the fancy of certain birds, so that for each island or group of islands there may be a particular bird claiming "eminent domain." As instances, there may be cited the possession of the South Chíncha and the Ballestas Islands by the white-breast cormorant, San Gallan by a diving petrel, one of the Santa Rosas Islands by the little tern (*S. hirundinacea*) and the Lobos Islands by the pelican, and the larger gannet. Off-lying islets may be taken by another species than the one occurring in principal abundance on the main island. Thus, in the realm of the cormorants at the Chínchas, a small rookery of pelicans occupied the flat top of an islet near the north island; while just across from the pelican rookery on Lobos de Tierra, a low islet was crowned with cormorants.

Briefly to indicate the economic significance of the guano birds, it may be recalled that a quantity of more than 10,000,000 tons of high grade guano is reported to have been extracted from the Chíncha Islands between 1851 and 1872. Such an amount of guano of the high grades then exclusively used would have a pre-war value of

¹ Examples of lizards and bats collected by the writer on the guano islands and deposited in the United States National Museum were identified as follows: *Phyllodactylus gerrhopygus* (Wiegmann), lizard from San Gallan Island, near the beach. *Phyllodactylus inequalis* Cope, lizard from Lobos de Afuera Island, near the beach. *Tropidurus peruvianus* (Lesson), lizards from Lobos de Tierra, near the beach, and from Chíncha North Island. *Desmodus rotundus rotundus* (Geoffroy), bat from cavern in one of the Ballestas Islands.

² The description of the islands is taken in part from an unpublished manuscript of the writer, which is in the hands of the National Geographic Society.

about three quarters of a billion dollars. Billion-dollar birds, they have easily been without exaggeration. Well before the close of the century the best ancient deposits were exhausted and the lowest grades were being sought. In the first years of the present century the exportation was in the neighborhood of 100,000 tons a year. At the present time it is less. The requirement of Peruvian agriculture as estimated in 1905 was 25,000 to 40,000 tons a year. While the remnants of the ancient deposits, so far as is known, are of the lowest quality (3 per cent or less of nitrogen), it is to be emphasized that the annual production of the birds, amounting in 1906-1908 to 20,000 tons or more, is of the highest grade, yielding by analysis from 12 to 17 per cent of nitrogen (with higher ammonia equivalent)

THE PENGUIN.

One of the most interesting birds of the Peruvian coast is the smaller penguin, *Spheniscus humboldti* Meyen (pl. 53, fig. 1). The Peruvians aptly call it the "pajaro-nino," or "baby-bird." Observed from a distance, the waddling uncertain gait and the stumpy flightless wings held out awkwardly inevitably suggest the manner of an infant toddling on the beach.

Undoubtedly the penguin was much more abundant on the coast many years ago than it is at the present. Raimondi,¹ at the time of his visit (evidently in 1855), mentioned that the penguin had quite abruptly left the north island of the Chinchas, was rarely found in the middle island, but was in "great abundance" on the south island at that time. This change of home was undoubtedly due to the operations of guano extraction that were being carried on upon the islands. At the present time a few penguins may be observed at any of these islands, but nowhere could they be described as abundant. The largest number seen at one time was on the beach of the Isla Vieja, in the Bay of Independencia, where about 60 birds were congregated.

The northward range of the penguin is surprising at first, but it is readily accounted for by the effect of the cold Humboldt Current, which, supplemented as it doubtless is by the upwelling of bottom waters, tempers the climate of the coast of Peru, even up to within a few miles of the equator. The farthest north I observed the penguin was at the islands of Lobos de Afuera in 7 degrees South latitude. At Guañape very young penguins were seen on the rocky shore in March, 1907, or late summer of the southern hemisphere. At the Ballestas Islands, a part of the Chinchas group, in May, 1907, the nests of the penguin were found commonly in some of the deeper caverns. Most of the nests contained eggs, some of which were just hatching; a month later a number of grown but immature

¹ Raimondi, A. Mémoire sur le guano des îles de Chincha et les oiseaux qui le produisent. (Extrait.) Compt. Rend. Acad. Sci., vol. 42, 1856, pp. 735-738. Paris. 1856.

birds were seen at the Bay of Independencia. These observations would suggest that the breeding season extends over the greater part of the year, since we find young penguins in late summer and eggs and immature young in early and midwinter. Two mature males that I killed were, respectively, 67 and 72 cm. long, 47 and 48 cm. in girth, and $9\frac{3}{4}$ and $11\frac{1}{8}$ pounds in weight.

Raimondi (1856)¹ makes the following interesting note regarding *Spheniscus*, which not only testifies to the much greater abundance of the penguin in past time, but comprises a valuable observation concerning their breeding places at a time when the caverns could not have afforded sufficient space for them.

The *Spheniscus* are abundant on the south island [Chincha group], which as I have said, was uninhabited [by guano workers]. It is probable that they have been driven from the north island by the ships that repair to that place in great numbers, and by the exploitation works. These birds, not being able to fly, seek shelter and dig for themselves a subterranean home in the guano itself.

At the season when I visited the islands [evidently September, 1855] they were occupied in incubating their eggs which are of the size of an egg of a turkey, and from two to four in number [p. 738 translated].

It was at the small islands of Ballestas, a sister group to the Chinchas, that I had the best opportunity to see the penguin. The bluff faces of these islands are marked by many caverns, some of which extend deep into the islands beneath the high table-like tops. The north island of the group is practically undermined on all sides by such caves. Rowing around this island we could see a number of penguins in couples or small groups in numerous hollows and small caves or "cuevacitas." Far back in one of the large caves a considerable number of these birds were conspicuous, even in the obscurity of that deep vault, for their glossy white breasts and lateral stripes. The stripes of the sides and backs were generally better marks than the breasts, since the latter, though naturally white, were often quite dark with the mud and manure of the nests. Directing our boat into one of these caverns we rowed up well under one of the great arches forming the double entrance, but were obliged to put back as the boatmen were afraid of being unable to handle their craft in the swell and among the rocks. Another cavern proved more feasible of approach; after being rowed back to where the water was quite shallow near the beach at the inner end, I could step into the water and wade ashore. Some of the penguins ran hurriedly into the water along the sides, while about a dozen retreated to the very back of the cave. As soon as the eye became accustomed to the darkness, fully a dozen nests could be seen, each with two large eggs. The nests were simply hollows in the larger rocks and covered with bones, evidently those of penguins.

¹ Raimondi, A. *Mémoire sur le huano des isles de Chincha et les oiseaux qui le produisent.* (Extrait.) *Compt. Rend. Acad. Sci.*, vol. 42, 1856, pp. 735-738. Paris. 1856.

The penguins are active indeed for walking birds and step along with quickly moving feet, but with an awkward movement of the upper part of the body, and with wings hanging out like stiff and useless little arms. When they have retreated to the back of their cavern they make no further effort to run out and escape, but huddle together and gaze stupidly at the intruder. They make a queer twisting movement with the head and neck so as to place first one side of the head toward you then the other, pausing a moment between each twist. When the natives capture them they do so by striking them on the back of the head with a club or with a stone thrown at them, for their bills are too strong and vicious in defense to make a close approach entirely safe. Once it is slightly stunned, a penguin may safely be taken up by the back of the neck. Even after an extremely severe blow they soon recover and appear to be in good health.

We kept a penguin at our camp for some weeks restrained by a long line (pl. 53, fig. 1). When it rested upon the rocks above the water, its round fat body and stout neck laid flat on the rock, its slick hair-like covering of short close feathers, and its outspread seal-like flippers, all gave it the semblance of a diminutive sea lion. Penguins are strong swimmers and, when free in nature, dive for considerable distances, coming up only for a moment's breathing and each time indicating their position by a peculiar cry, a slightly prolonged hoarse note of a single pitch, much like the sound of a toy trumpet. At night they are frequently heard to bray in such close imitation of the donkey, that one might well be deceived except for the knowledge that the vicinity is that of a desert island.

The penguins yield a guano which is generally esteemed, and is regularly sought, but, because of the greatly reduced abundance of the birds and the conditions surrounding the nests in the deep, damp caverns, the fertilizer derived from the penguins is deficient now both in quantity and quality. The birds are frequently killed by the fishermen or guano workers, who esteem not only the oils derivable from them, but the skins which are well adapted for the making of warm "fur" caps.

THE GULLS AND TERNS.

The most common gulls of the Peruvian coast are the large white "gaviota," "cleo," or "cau-cau," *Larus dominicanus* Lichtenstein, a smaller white "gaviota" or "simeón," *Larus belcheri* Vigors, and the slate-colored "matéo," *Larus modestus* Tschudi. The matéo was generally observed south of Callao. The two gaviotas are so much alike in color that the two species are readily confused at a distance. At closer view, *L. belcheri* is easily distinguished by its smaller size, its red-tipped bill, and bright yellow feet and tarsi; the feathers of

the back are pearly white, and not *pure* white as in the larger species. As I observed it this species was wilder, being found more commonly about outlying rocks, while the *dominicanus* is the familiar visitant of the beaches and fishing camps. The following notes refer to *Larus dominicanus*.

LARUS DOMINICANUS Lichtenstein.

THE GAVIOTA.

The gaviota, or Dominican gull, is so generally distributed over southern seas and so familiar to travelers and seamen that one hesitates to imagine that the observations of any but the most experienced ornithologist could add to existing knowledge regarding it. Nevertheless, to exclude the gaviota from the present account would be to leave the picture of bird-life upon the islands too incomplete, and to ignore a most significant element in the bionomics of the bird communities.

Though not equaling most of the other birds of the islands in abundance, value, or interest, the gaviotas form an important element in the aesthetic effect and keep one most insistently reminded of their presence (pl. 55). They frequently follow one about, circling slowly over-head and uttering harsh cries. They manifest a greater diversity of habit than any other of the familiar sea birds. Though not strictly gregarious, they are often seen in flocks of some hundreds, resting drowsily on some interior flat of guano or sand and appearing like groups of white balls on a dark background. More often they are seen isolated or in groups on some slope commanding a view of the water. Favorite positions are on salient points of the shore or small outlying rocks projecting a little above water. Again they are found far away from the islands, floating on the waves or flying slowly after a vessel watching for offal.

The gaviotas make four or five different calls: the familiar *caw, caw*, in flight; the prolonged laugh, *ha-ha, ha-ha, ha-ha, ha-ha, ha* (or *cah-cah*), when standing; a softer and shorter *ca, ca, ca, ca*, (like *ca* in "call") repeated rapidly and staccato while flying; and a sort of clucking sound when at rest.

Near the large fishing camp at Lobos de Tierra, large numbers of the gaviotas regularly congregate to feed on the waste matter at the camp. It was repeatedly observed that while the birds would feed even between the feet of the native fishermen they would fly quickly at the approach of a white stranger.

Gaviotas are not only scavengers of the beaches and rookeries, but are most pernicious in their depredations upon the nests of other birds. I have seen them taking the eggs and fledglings from the nests of pelicans and piqueros, and even robbing eggs from other gaviotas. They break the eggs at the nest or take them into the air and let them fall to break on the rocky ground. They will swallow

entirely a new-born pelican (with considerable effort) or tear a larger one to pieces, contending with the turkey buzzards over the common prey. The concerted attacks of gaviotas and gallinazos on the nests of piqueros is described in another place (p. 498).

Besides doing scavenger duty in the rookeries by feeding on discarded fish or dead bodies of birds, they were not uncommonly seen perched on the floating body of a pelican, which had perhaps been killed by a sea-lion, and tearing at the meat, a position undisputed by the gallinazo. I was interested to determine if they were themselves afraid of the sea-lions. They would always desert a floating body as a sea-lion approached and, though they will rest on the water with the sea-lions nearby, they fly invariably to another position as the "lobo" draws too near.

The nests were found in December, principally at Lobos de Tierra, but a few were observed at Lobos de Afuera. They were generally on the hills, scattered among the nests of the larger piqueros, and lined with a few feathers and seaweed (pl. 56, fig. 1). Three nests were found under the shelter of a low bank upon a beach and close to the water. There are almost always three eggs or young, although one nest was found with five eggs. The eggs are olive green, spotted and blotched with dark brown (75 by 50 mm.). The very small birds have a black bill with light tip, and are covered with thick soft down, gray in ground color but brindled with fuscous; the head is distinctly spotted with dark fuscous on a light gray background. When quite young they will run about, leaving the nest to hide among the rocks as an intruder approaches.

The gaviotas have a variety of color phases with the age and season. The head, at one stage dark gray or nearly black, becomes white-mottled and then pure white; the black tail with white base and tips becomes a white tail with narrow black bar.

The nests of the gaviotas are practically devoid of guano, so that their economic significance depends principally upon their service as scavengers and, on the other hand, their depredations upon other birds.

STERNA HIRUNDINACEA (Lesson).

THE TERRECLE.

Among the terns, particular attention was given only to the "terrecle," *Sterna hirundinacea* (Lesson),¹ and the "zarcillo," *Larosterna inca* (Lesson).

The terrecle is very common in the southern region particularly. The principal breeding places observed were San Gallan (June 25) and the Islas de Santa Rosa at the Bay of Independencia (July 18,

¹ The bill was deep blood red and the tarsus a brighter red, in the specimens of *S. hirundinacea* collected, although Taczanowski describes the parts as yellow and yellowish. The outer third of the upper bill of one specimen was almost black.

1907). This was in midwinter. On the south Santa Rosa, a relatively low, flat-topped island, the nests lay so thickly on the ground, and the eggs were so inconspicuous among the small stones, that, despite great watchfulness, one could not walk about without crushing the eggs. The young birds, however, stood in little danger, since even in the fledgling stage they were wary and exceedingly active; they would run quickly away even to a distance and become almost invisible beside a small bit of gravel. No other birds of the islands were observed to be either so active or so successful in concealment. In the stomachs of two specimens examined there were found chiefly small fishes, the common anchobetas, *Engraulis ringens* Jenyns.

Another tern, very similar to the terrele in markings, though greatly different in size, is the little *S. lorata* Philippi and Landbeck, the "Churi-Churi" of Paracas Bay, where it was seen most abundantly.

LAROSTERNA INCA (Lesson).

THE INCA TERN OR "ZARCILLO."

One of the most fascinating birds of the coast is the beautiful Inca tern, *Larosterna inca* (Lesson), known in Peru generally as the "zarcillo." At Eten they call it "aronito." Although noted as far north as Lobos de Afuera, it was observed in greatest abundance in the southern region.

The body color is almost uniformly a dull dark blue, but the head and the outer parts of the wings are a little darker, while the under side of the wings is lighter. From the lower part of the base of the upper jaw a pure white band, or "moustache" extends backward, below the eye and just above the yellow fleshy flaps, to the region of the ear; there it ends with a half-dozen long slender little plumes that emerge from the feathers, and curve backward, downward, and outward in graceful manner. "The bird with the white earrings" a visitor termed it.

It is altogether a most pleasing bird in its grace of form and movement, as well as in its strikingly neat and even dandified appearance. The soft dark blue of the plumage is effectively varied by the crimson of bill and feet, the white margin of the wings, the yellow flaps at the gape of jaws, and the showy "earrings."

In flight it apparently delights in sharp curves, quick reverses of direction, or sudden drop with webbed feet outspread. The forked tail presents a variety of forms in these maneuvers, now widespread and fan-shaped losing all trace of the fork, now closed in swallow-tail effect, or, again, so snugly closed as to obscure the forked form entirely.

The Inca terns have a most inquisitive habit. Even when there was no probability of being near to the nests, they would circle rapidly

about one, now and again making startling dashes straight for the head, to swerve sharply aside when within but a few feet. The desire to investigate seemed at first the probable motive for such flight. They were observed to practice the same maneuvers over our captive penguin swimming in the water. It is possible that such sudden startling dashes would have the effect of causing larger birds or animals to drop a morsel of food which could be seized upon by the alert terns.

The plaintive call of the Inca tern is somewhat like the cry of a young kitten; although sometimes petulant, it lacks the harsh tone of other terns.

The breeding places of zarcillos are found on many islands; generally they were observed to use the trenches or other places where the surface crust had been broken away in guano extraction, and where the nests could readily be concealed by excavating little tunnels in the bank (pl. 54). Nests with all stages of eggs and young were observed at the Chincha Islands (North Island) in June, 1907. One of the most populous breeding places was the Isla Asia visited in August of the same year. I have no record of nests observed in the summer season although doubtless there is little interruption of the breeding season.

None of the terns have any noteworthy value as producers of guano. A native described the Inca tern as good to eat.

The skimmer, *Rynchops cinerascens* Spix, doubtless frequents the northern islands although I did not observe it near any island. A specimen was taken at Tumbes in January, 1908, where it was not uncommon. Both Tschudi and Raimondi noted its presence at the Chincha Islands (pp. 507 and 508, below).

THE ALBATROSS.

The albatrosses are represented by the "pajaro-carnero" (mutton-bird), or "pajarote," *Diomedea irrorata* Salvin, a beautiful bird, with dusky brown body and white head and neck, little exceeding a cormorant in size of body, but with wing expanse of 8 feet (2½ meters) (pl. 53, fig. 2). The specimen shown in the illustration was captured when wounded on the ocean and was kept in captivity for some time. Naturally it did not lend itself to domestication and it never consented to take food. The albatross was always seen either flying low over the water or resting upon the surface. Its wing strokes seem slow and deliberate, but the flight is rapid and graceful. It will soar for considerable distances, keeping just above the water and rising and falling with the waves. When resting on the water, and at a distance, one might easily confuse it with a gaviota; but at nearer range its flight and its longer bill readily distinguish it. The pajaro-carnero was observed from the Bay of Independencia in the

south to the Lobos de Tierra in the north. While it was more frequently seen in the south, yet on one trip made in a small boat from the island of Lobos de Tierra to Eten on the coast the pajaro-carneros were nearly always present in numbers; often 30 or more were in view at one time. One was observed devouring a fish about a foot in length.

The pajaro-carnero was never seen on land, and presumably does not breed in that latitude. Native fisherman assured me that the bird never alights (in that latitude) except upon the high sea: "Paran en la altura, no mas."

THE PETRELS.

The family of Procellariidae is well represented on the Peruvian coast, by the Wilson's petrel, stormy petrels, several species of shearwaters, and the diving petrels. The "pardela" *Puffinus griseus* Gmelin, is a sooty shearwater, frequently seen swimming lazily on the surface of the water and relatively tame. I think this is sometimes called "doña." Another and somewhat smaller species, the "pardela tablera," was observed but not taken.

Numbers of small petrels, the stormy petrel, *Procellaria tethys* Bonaparte, the Wilson's petrel, *Oceanites gracilis* Elliot, and others, were frequently in evidence, skimming lightly over the surface of the water or hovering over a school of small fish which was being pursued by bonitos. The stormy petrel is known as the *danzarin* or "dainty dancer"—the most appropriate name possible—descriptive both of its swift, graceful, swaying flight close over the water and of its light, dancing movement with feet and wings when feeding. As we went by sloop from Pisco to Independencia, numbers of them followed our vessel picking up the crumbs thrown into the water. The *danzarin* seems to alight on the surface of the water, the wings stopping outspread for a moment as they follow the upward and downward movement of the wave. A slight flirt of the wings and the bird is resting again on the surface only a few inches away, while it daintily picks the bits of food from the water.

PELECANOIDES GARNOTI (Lesson).

THE DIVING PETREL OR POTOYUNCO.

Among the petrels, one is of particular interest and importance, the "potoyunco," *Pelecanoides garnoti* (Lesson), a diving petrel, an abundant bird, and a significant guano-producer. In favored locations on the islands they are breeding at all seasons and the guano left in their subterranean chambers is considered particularly rich in nitrogenous matter.

My first acquaintance with these birds was when at night in a small boat we often sailed close by them floating on the surface of the water

and apparently quite unobservant of the boat. Not more than once did I see them on the water by day, though the fishermen said that but one bird of the pair is at the nest during the day, the other remaining out on the ocean. On the islands, as far as my observations go, they are strictly nocturnal, coming and going only after daylight has gone and before the light of morning. They are more readily recognizable by sound than sight, and, as they fly obscurely about over the island, uttering their little croaks, they are very suggestive of bats.

The nests are made in the side of the hill, often just beneath a large rock or sheltered under the hard salty crust. It is an odd experience to sit at such a place and hear the mysterious sounds from subterranean homes. Over and over again, with the voice of a frog, unvaried in pitch or rhythm, they repeat the sequence of notes—two longs, a short and a long, the last note slightly longer than the first two. Another more complicated sound is made by some and it is possible that the calls are distinctive of the sexes.

The potoyunco is comparatively small, measuring about 10 inches in full length from end of bill to tip of tail and weighing half a pound. The general color is black above and white below. The body is thickly covered with feathers, beneath which is a thick gray down, the dense coat making the bird appear to possess a very large body. Viewed from below, the body is oval in form—like a large white egg—the wings and the short, stout neck seeming disproportionately small appendages.

A number of the nests were observed at the Ballestas North Island, and the birds were heard on the Chinchas, but the lofty San Gallan was the chief island for potoyuncos, as the potoyuncos were easily the principal bird of this large island.

San Gallan, 2.5 by 1.5 miles, is mostly dry, barren, and dusty, but with high hills reaching well into the clouds, and only there, in the moist altitudes, teeming with plant life. Everywhere over the island are large spots perforated by the holes of the potoyuncos, as they undermine the hard, dry crust of the lower hillsides or burrow back underneath the vegetation of the cloud-wrapped peaks more than a thousand feet above sea level.

Searching for these birds in the daytime one is guided only by the openings of the burrows, for their voice is rarely heard during the day. One may try quite a number of nests without result, as the burrow may either be unoccupied or, more often, too deep for the arm to reach to the nest. Still, so abundant are the nests on San Gallan, that a considerable number of birds or eggs may be captured in an hour or two. Once reached, the birds are easily taken, as they make almost no effort at resistance. Sometimes, after they are out, they try to bite, but without inflicting injury. Occasionally they would rush into the hands held at the mouth of the burrow.

At night it is much easier to take them, when guided by the voices one may avoid exploring the unoccupied homes. It is thus that the laborers and fishermen catch them abundantly, for the potoyunco is valued for food in fresh or salted condition.

If liberated they run rapidly over the ground flapping their wings, but unable to rise except after a run of 10 or 20 feet. Then, with exceedingly rapid movement of their short wings, they make for the ocean with a queer zig-zag flight. Reaching the ocean they fly low over the water a little distance, settle upon the surface, and then swim away with short, shallow dives.

When placed on the ground in my tent, the petrels displayed peculiar movements. The body is covered with a very thick coat of feathers so that lying on the ground the body seems to flatten out remarkably, while the wings, pushed a little out on the sides, increase the apparent width until the body has quite a turtle-like form. As they crawl rapidly along, the legs are spread well out to the sides and the body is barely, if at all, lifted from the ground. I noticed that with some the body was slightly raised; with others not at all. In any case the movement is a reptilian creep rather than a walk. When I started one under my sleeping bag it began to burrow, with strong backward sweeps of the feet, used alternately and sending the dirt flying with great force. Two birds were placed outside in holes in the ground, each secured by a line attached to the leg. They made a little effort to burrow, but soon stopped. At 10 o'clock at night I found them trying to go toward the water. Placing them back in the holes I left them again, hoping to ascertain the rate of excavation. Unfortunately, in the morning only the bones of the legs remained, and the tracks of gallinazos accounted for the disappearance of the birds.

Presumably both condors and gallinazos (buzzards) may be accounted enemies of the potoyuncos, although their subterranean life and nocturnal flights give them substantial protection from predatory birds. Certainly the chief enemy is man. About the signs of old campfires numberless wings of the potoyuncos were often observed. For a while I was puzzled by the many signs of sacks having been dragged down the hillsides, until it was observed that these trails led in almost every case to the grounds where there were burrows of potoyuncos, even to those near the very tops of the peaks. The ground was not torn up as if guano had been the object of search, and the abundant evidence of discarded wings of potoyuncos completed the story. The fishermen assured me that these birds were very good when salted, and that the laborers on the islands regularly brought back quantities of potoyuncos salted down. The fishermen with me asked permission to take the birds for food. This was refused; but with little effect, for I counted 21 birds drying

in the sun one morning and know that they had first eaten all they had wanted.

A great many nests were examined, to find in each nest, if tenanted, only one egg or one young bird. The eggs are purest white, with very thin shells, and they are very variable in shape. Some are short and well rounded, with little difference between the ends, while others are very elongated and rather pointed at the smaller end. The measurements of six eggs of the potoyuncos were as follows:

Dimensions, in centimeters, of eggs of Pelecanoides garnoti.

	1	2	3	4	5	6
Length.....	4.85	4.75	4.5	4.5	4.35	4.3
Transverse diameter.....	3.1	3.6	3.4	3.3	3.3	3.4

A "pichon," or fledgling, at the stage when the wing feathers are first appearing, is a large shapeless mass of fat and down, with nearly the dimensions of its parents and of equal weight (about 7 ounces). Its soft coating of gray down measures 3-4 cm. in thickness (1½ inches, more or less). If a single tuft of down is pulled out, there is found growing out of the blue sheath the delicate little feather, which for about 1 cm. is white (if from the lower side of the body) or black (if from the back); many of its barbs are tipped with delicate plumes of down, which are dark gray for about 2 cm. and possess white tips of 1 cm. length. The head protruding from this great ball of down appears almost bald having only a close crop of gray down.

Valued as they are for food and readily open to capture, the potoyunco must eventually be brought near to extinction unless effective efforts for its protection are made. It will be unfortunate, indeed, if the potoyunco and the penguin, two water fowl which produce a fertilizer of high quality, shall, through mere human negligence or wastefulness, become lost to the guano industry. Valuable the potoyuncos may be as food, or the penguins for the skins or fat, and we may impose little personal blame on those who desire the food or the skins or the oils; but the fact remains that when the food or the skin and oil is taken the bird is lost to the future, while the removal of the guano is a benefit gained without loss. With due care each of these important species may not only be preserved to the future, but may be restored to a condition of far greater abundance and value than at the present time.

THE GANNETS.

The Sulidae or gannets are represented on the Peruvian coast by two species, the abundant *Sula variegata* (Tschudi), third in importance

among the guano birds, and the larger but far less common form of the north, *Sula nebouxi* Milne-Edwards. Along the greater part of the coast *Sula variegata* is known as the "piquero."¹ In the north, however, as at the Lobos Islands where the larger species of *Sula* is found, the latter is called "piquero" while the smaller *Sula variegata* is commonly known as the "camanay."

SULA VARIEGATA (Tschudi).

THE VARIEGATED GANNET OR "PIQUERO."

The common "piquero," sometimes called "camanay," is a beautiful bird with head, neck, and breast of pure white, the back and upper surface of wing variegated with dark and light fuscous and white, while the sides and belly are nearly pure white; the feet, legs, and bill are blue, and the eyes are ruby in color (see pls. 57 and 58). The piqueros are almost omnipresent on the Peruvian coast, and undoubtedly they are the most abundant of the sea fowl. Along the mainland shore and about the islands of any size, there is scarcely a cliff but is more or less dotted with the nests of piqueros (pl. 59).

It is a striking sight when a single gannet, after circling over the water until its food is seen, turns suddenly head down and falls precipitately into the surface of the sea to disappear from view; after a few moments it reappears on the surface to swallow its prey before rising to fly at varying heights until tempted for another plunge. Sometimes they seem to drop from nearly a hundred feet, while the wings are held slightly opened to direct the head-long course; again they fall from only 10 or 15 feet, or they may simply dash themselves into the water when barely risen from the surface. Ten or 20 or 30 birds are not infrequently seen to fall simultaneously with a loud splash and dash of spray.

The writer had a rare experience that seems worthy of record. While passing from the Chincha Islands to Pisco in a fisherman's row-boat, we saw an actual cloud of thousands of piqueros flying over a school of anchobetas, when suddenly they began to fall, hundreds at a time until practically the whole cloud was precipitated into the sea before the first birds had risen from their brief rest after emerging from beneath the surface. Scarcely a bird was seen in the air. The first to fall were soon up, however, and from that time on the plunges were uninterrupted. Changing the course of our boat a little we soon rowed directly through this downpour of birds. Hundreds of birds seemed to strike the water at every instant, and even within a few feet of our boat. The bewildering effect is to be imagined rather than described; the atmosphere "cloudy" with birds; the surface of the sea broken and spattering from falls of animate drops and speckled

¹ Pronounced pē-kā'-ro. Accent on second syllable.

with reappearing birds; the confused sounds of whirring wings and unremitting splashes.

The food of the piqueros, as far as I observed it, consisted principally of anchobetas, *Engraulis ringens* Jenyns; like other sea birds they doubtless feed upon what is most readily available, and they too, doubtless, regale themselves with the small crustacean, *Munida cokeri* Rathbun, which is sometimes so abundant as to form veritable "red seas" of great area.

The piqueros seem to prefer the rougher and more inaccessible places for breeding (see pl. 59). Thousands of their nests may be seen upon the face of abrupt cliffs, as at the Chincha Islands; at that particular place they overflowed the cliff, so that a few nests were found on the level ground at the top. This, in fact, was the only place where piquero nests were seen on real table-land. At Guañape (pl. 58) and Lobos de Afuera, many nests were found on very steep and rugged slopes high above the water and approachable only with considerable difficulty. The nests are hollowed, shelflike masses of guano built on some scant ledge, and are usually as closely crowded as circumstances permit. The adult birds readily desert the nests on the approach of an observer, and one must wait with some patience for their return. Since the breeding season is continuous throughout the year, one may at any time find eggs and all stages of young. The nests contain from 1 to 4 eggs, a considerable proportion of them having as many as 3. Nine out of 25 nests counted at one view had 3 eggs. The eggs are a pale blue, smeared more or less with a white, chalky coat, are little pointed and are generally rather uniform in size. The measurements of 5 specimens from the Lobos de Afuera Islands (December 1908) and of 3 from the Chincha Islands (June, 1908) are as follows:

Dimensions, in millimeters, of eggs of Sula variegata.

	Lobos de Afuera Islands.					Chincha Islands.		
Long diameter.....	53	61	62	62	61	60	62	59.0
Transverse diameter.....	40	43	43	44	41	42	43	39.5

The immature birds have the skins of exposed parts of the same color as in the adult except that the tarsus and feet are lighter, in effect a bluish gray. The iris, however, is yellowish gray, instead of clear ruby, as in the adult. The primaries, secondaries, tertiaries, greater and middle coverts, scapulars, and tail feathers, appear before the birds are of full size (pl. 56, fig. 2). Specimens with the breast and belly feathered, upper tail coverts present, and back feathers appearing, show the adult measurements. The feathers of the breast and belly are of light fuscous or gray widely margined with white. The

feathers of the shoulders are dark fuscous scarcely tipped with white, and a band of similar feathers extends to the breast around the base of the still down-covered neck. The upper surface of the wings is as in the adult, except that the colors, as everywhere on the body, are duller. A conspicuous feature of the immature birds is the cross of white down on the rump which long persists while the rest of the body is becoming fully feathered. The predominant white colors of the adult bird are not evident until a late phase. The young when abandoning the parental nest have practically the entire head, neck, and body a variegated fuscous. At this stage the birds are easily confused with the larger species, *Sula nebouri*, unless the measurements are considered.

The young birds go through much home practice in flight before starting away from the nest. They will stand in the nest flapping the wings continually for a long time, or, facing the wind and assisted by its power, will rise in the air to remain in an almost fixed position for a considerable time flapping the wings strongly all the while, and then gradually receding to the nest. These practice flights were repeatedly observed, the young birds getting only 3 or 4 feet above the nest and 2 or 3 feet forward, and thus remaining for a minute or more.

Von Tschudi¹ ascribed to the *Sula variegata* the chief rank as a guano producer, and his mistake has been frequently followed. There is reason to believe that the habit of this species as regards choice of nesting site has undergone some modification since Tschudi's time.² Tschudi was a very careful observer and he spent some years upon the coast, but he expressly states in his Ornithologie (p. 313) that none of the birds nest on the mainland, but only on the barren islands. Such a statement certainly could not be made in the present time. Unless the habits of this bird have materially changed during the past 70 years, Von Tschudi was misled by observation of the evident abundance of the Sulas; and his mistake has been too frequently followed in nearly all reference books. This species now ranks a very poor third in economic importance, being far exceeded by the cormorant and the pelican. Yet this may not be the case in future. As has been previously mentioned, the piquero frequents the rough and scarcely accessible places and even the abrupt cliffs; and, while practically no place is entirely inaccessible to the intrepid guano workers, it is evident that from such positions a large proportion of the guano must be lost by falling to

¹ Tschudi, J. J. von. Travels in Peru during the years 1838-1842. Translation by Thomasina Ross. New York, 1852 (p. 168). Also,

Tschudi, J. J. von. Untersuchungen über die fauna Peruana. 2 vols. St. Gallen, 1844-1846. Vol. 2, Section: "Ornithologie" (p. 313).

² Raimondi also believed that *Sula variegata* produced more guano than pelicans or cormorants, because they keep themselves in the interior of the island (not confirmed by a later statement. See p. 503.)

the water below, and that even entire nests will break away when too heavy and drop into the sea (pl. 59) In some cases, a small beach below may serve to collect the falling guano and keep it available for extraction.

It is not thought to be by any means physically impracticable to build shelves at the base of cliffs or to contrive other means for conserving the waste guano from the nests in such places. This will not be done, however, so long as the extraction of guano at any particular situation is subject to lease to any one of several competitors. The contractor who would incur large initial expense for construction of such equipment must be assured, not only of his own exclusive privilege of taking the guano from such situation, but also of his license and power to protect his property from depredation or damages. Von Tschudi found that a single *Sula variegata* (piquero) in captivity would produce $3\frac{1}{2}$ to 5 ounces of guano a day. (See his Travels, p. 169.) Supposing 1 ounce of this to be deposited at the island each day (a low estimate), it is evident that a thousand piqueros would produce 365,000 ounces a year, or $11\frac{4}{10}$ tons a year—or a million birds 11,400 tons, say, practically half a million dollars' worth. The numbers of Sulas on the Peruvian coast and islands would far exceed the million. The piqueros, therefore, offer one of the best opportunities for hope of increase in the amount of extractible guano.

One of the illustrations shows a cliff at the Chincha Islands on which there were at least 1,000 nests. Guano to the amount of many tons is formed at such a place each year but is almost entirely wasted by falling into the sea.

It has been mentioned, too, that in this case, at the Chincha Islands, a few piqueros were found to have their nests on the table lands beyond the top of the cliff. It is not impossible that, were the islands less frequented and the bird quite undisturbed, a larger proportion would frequent the level ground where the guano of the nests would be entirely preserved. This appears to have been the case in the time of Raimondi.¹

While the *Sula variegata* occurs along almost the entire coast of Peru, it is more especially a bird of the southern region. Very abundant as far north as the Guañape Islands, it is less conspicuous there; there is, however, a considerable rookery at the Lobos de Afuera Islands still farther north. A little farther north, at Lobos de Tierra, this species is far less numerous; the other and larger species of *Sula*,

¹ Raimondi, A. Mémoire sur le huano des isles de Chincha et les oiseaux qui le produisent. Comp. rend. Acad. Sci., vol. 42. Paris, 1856.

Raimondi, Antonio. El Peru—estudios mineralogicos y geologicos. (Ser. 1.) Volumes 1-4. Publicado por la Sociedad Geographica de Lima 1874-1902. Article entitled: Apuntes sobre el huano y sobre las aves que lo producen. In volume 4, 1902, pp. 489-496. This article is evidently based upon the earlier paper just cited, but seems to represent a revision.

next to be described, takes its place to some extent. In going north, the *nebouxii* was first seen in any numbers at Lobos de Afuera, where the diminution in abundance of *Sula variegata* was first detected.

An account of *Sula variegata* in the Galapagos Islands is given by Snodgrass and Heller,¹ but their observations regarding the habits of this bird are at variance with mine. They say:

No nest is constructed and generally only one egg is laid by each female. On Culpepper Island we saw some nests containing two. They snap their beaks viciously at the foot or leg of the intruding person, and a nesting bird can not be forced to leave her egg.

They observed the nests apparently only upon the level ground. The measurements which they give, however, are far too large for those of *Sula variegata*. Every measurement given in their table on page 245 is from 10 to 20 per cent too large for *variegata* if the measurements of my specimens taken in the type region are correct. They also state that the bill is "light orange-red, yellowish at the tip and along the commissure," which does not conform to the original description of the species. *Sula (Dysporus) variegata* was described by von Tschudi from the coast of Peru (Ornithologie, p. 313), and, while his description is not given in great detail, it is unlikely that my specimens were far from being typical. It seems possible, therefore, that their identification was incorrect. *Sula variegata* has a bluish horny colored bill, nests in Peru now chiefly in rough or precipitous places, and has from 1 to 5 eggs for each nest. The adults are not relatively noisy and desert the nests readily when approached.

It may be noted that the specimens from which the measurements of Snodgrass and Heller were made were fully as large as the specimens of *Sula nebouxii*, although *variegata* is a much smaller bird. Their observations of the color of *nebouxii* agree with mine. Their statement that its breeding habits are different from those of both *S. variegata* and *S. piscatrix websteri* in that it invariably nests on cliffs would indicate a very striking difference of nesting habits between the birds of the same species on the Galapagos Islands and the Lobos de Tierra relatively. *S. nebouxii*, as related below, was never observed nesting except on the more level ground. Nelson² gives some account of *nebouxii* as observed on the Tres Marias Islands, west coast of Mexico. Nelson writes:

They were breeding abundantly on the beaches and on a low flat area that covers a part of the former island (Isabel). They were most numerous on the open beach a little above high-water mark, but dozens of them were seen with their eggs farther back among the bushes [p. 31].

¹ Snodgrass, Robert Evans, and Heller, Edmund: Papers from the Hopkins-Stanford Galapagos Expedition, 1898-99. XIV. Birds. Proceedings Washington Academy of Sciences, vol. 5, pp. 231-372. 1904.

² Nelson, E. W. General account of the islands with reports on mammals and birds. In: North American fauna. No. 14. Natural history of the Tres Marias Islands, Mexico. United States Biological Survey, 1899. pp. 1-97.

Raimondi's observations of the nesting places of *S. variegata* (quoted on p. 508, below) agree essentially with mine.

SULA NEBOUXI Milne-Edwards.

THE PIQUERO MAYOR (GREATER PIQUERO).

The larger *Sula*, the blue-footed booby, gray gannet, or "piquero," was not observed south of Guañape Islands ($8^{\circ} 35' S.$), and it was, therefore, a surprise to me afterwards to learn that the range of the species is given as from the Gulf of California to Chile. The original specimen described by Milne-Edwards¹ was assumed to have come from Chile, but it is not clear upon what evidence the southern records are made.

In color and habit the blue-footed booby is in striking contrast to the smaller white-head species, except in the manner of feeding and in this there are noteworthy differences. The showy white markings of the *variegata* are wanting, the plumage of all upper parts being variegated, and the eyes are yellow instead of ruby (pl. 60). In breeding habit the nests are widely scattered on the level ground or gentle slopes. In feeding, the *nebouxi* was often observed to use localities which the *variegata* did not frequent. At the Lobos de Tierra islands the gannets of the larger species were almost constantly feeding in the very shallow water near the gentle beach in front of our camp. The white-head gannets frequently passed over this place but never plunged into the shallow water. I never observed them feeding except in the deeper waters and generally plunging from some height.

The gray gannets would circle about over the bay, often with the bill pointing directly down, as they searched the water for their prey. If a little off-shore they might plunge from some height, but, in the shallow water two or three feet in depth near the beach, the drop was made from only a few feet above the surface or else the bird dived at an angle when flying barely above the water. Between times they were resting with the pelicans on the low rocks near-by.

When this piquero plunges, the wings are held out angularly, and just as the bird is about to enter the water the wings are folded to the body. The bird emerges very promptly and may rest a few moments on the surface or at once arise in flight. Sometimes it seemed to find itself too high for the contemplated drop, when it would descend by a spiral course of flight to a proper level for the plunge. I observed a gannet dive vertically from the air into the water that was only about 6 inches in depth, while another more prudent bird dropped to its feet in the water at nearly the same place and then secured his prey. It is interesting to note how frequently the piqueros of this

¹ Milne-Edwards, A. Recherches sur la faune des Regions Australes. Annales des Sciences naturelles Zoologie, ser. 6, vol. 13, art. 4, pp. 36, 37. Paris, 1882. [See p. 37 and pl. 14.]

species are associated with the pelicans. A few are often seen standing among a group of pelicans resting on a hillside. They not uncommonly accompany the pelicans in flight, and I have seen them joining with the same birds in the characteristic bathing act. When flying from the land the *nebouxi* rarely rises except after using its feet on the ground for a few yards, just as the pelicans do; yet they will rise at once from the surface of the water, and without the slightest apparent difficulty or delay. On the whole, the larger gannet is less active in flight and far inferior to the white gannet in grace and elegance of form and body.

The nests are not made in compact rookeries, but are widely scattered over the hills and valleys for many square miles of the island and are interspersed with nests of gaviotas (pl. 56, fig. 1, and pl. 60). As with the other species, no labor appears to be expended in the construction of the nest. The eggs or young are usually found in a slight hollow in the ground which is, however, apparently but an incidental result of the movements and the deposits of the nesting birds. In the newly formed nest with a single egg, the hollow is scarcely perceptible, but with longer use the nest becomes very distinct. After the young birds are able to stand and to move about, all traces of a nest disappear until soon there is no clue as to where the eggs were laid.

The nests contained from 1 to 3 eggs or young; thus, of 54 nests examined, 18 contained 3 eggs or young birds, 25 contained 2 eggs or young, while 11 had only 1 egg or 1 nestling. In no case did the young birds, whether 2 or 3, seem to be of the same age—there was always a series, as if hatched at different times. (See pl. 60, fig. 2.) Of 39 nests without unhatched eggs, 12 had 3 young, 19 had but 2, and 8 had only 1. The eggs are pale blue, having a distinctly blue shell mostly covered by a thin bluish chalky coating. The form is various but usually ovoid and rather elongate. The measurements of several eggs were as follows:

Dimensions, in millimeters, of eggs of S. nebouxi.

	Long diameter.	Transverse diameter.		Long diameter.	Transverse diameter.
1.....	64	40	5.....	60	44, 2 eggs from one nest.
2.....	67	39	6.....	65	40.
3.....	65	38	7.....	61	61.
4.....	63	41, 2 eggs from one nest.			

A very small egg that measured only 49 by 35 mm. was found to have no yolk.

The adult birds of this species excel all other birds of the islands in the boldness with which they will defend their young. If only

eggs are present the parent birds will, after some threatening croaks or whistles, fly when the observer is within a few feet; but they will cover the small young, or stand by the larger nestlings, and often vigorously defend them with their bills. When first examining the nests, it was necessary sometimes to push the bird from the nest to discover the young occupants. Once separated from the nest, the bird gives up the fight and flies away some little distance to remain until the intruder departs. The gallinazos, however, are usually even more prompt than the parent to find the exposed nest and eagerly devour the eggs or young. On a later page it is told how a gallinazo or a gaviota will provoke a gannet to attack in defense of its home, while other birds will then ravage the nest. As with the other gannets and the pelicans, it is the habit of the *neboux* to disgorge the fish from its crop before starting in flight, presumably by way of "throwing over ballast" to facilitate escape.

There are very evident sex distinctions. In every pair, one has a large black pupil and narrow yellow iris and quawks vociferously when an intruder approaches the nest; the other has a small pupil and broad iris, manifests a darker ground color of head, and utters only a hoarse whistle when approached. The supposition that this distinction corresponds to sex was not verified at the time by killing the birds for examination of the gonads, but I find that, of the pair which I killed and sexed on another occasion, it is the male which displays the darker ground color on the head, with more sharply contrasting white streaks, and the same is true of other specimens in the United States National Museum. Of 23 nests in which the parent birds were carefully noted, 11 were covered or guarded by the male (whistling parent with darker head, etc.), 8 by the female (quawking parent), and 4 by both. The immature but grown young are much darker than the mature males or females especially as to the head, and they show no yellow in iris. All the young seem to make the quawking sound.

The season of breeding seems to be uninterrupted. When the Lobos de Tierra Islands were first visited, March 29 to April 6, 1907, nests with eggs, with newly hatched young, or with feathering birds, were found in nearly equal proportions; and this was also the case at the second visit in early December of the same year.

In spite of its habit of nesting upon the level and accessible places, this species does not seem to be of high relative importance for its guano production. Its guano is so widely scattered over the ground as not to be readily appreciable in a season, but undoubtedly, in the long run, the production of guano is of distinct value.

The distinctive features of the two Peruvian species of *Sula* are indicated by the following comparison:

	<i>S. variegata.</i>	<i>S. nebouxi.</i>
Measurements.....	10 to 20 per cent greater.
Iris.....	Ruby.....	Pale yellow.
Foot and tarsus....	Dull blue.....	Brighter sky blue.
Head and neck....	Shining white.....	Brown spotted and streaked with white.
Breeding habit....	Nests on roughest places or on cliffs, as closely aggregated as possible.	Nests on the level ground or gentle slopes, widely scattered, along with nests of gaviotas. Bold in defending young.
Habit, general....	Clannish—not often seen at rest except at the rookery.	Spends much time on the islands, resting on the rocks of the shores or on the hillsides, frequently with the pelicans.

THE CORMORANTS.

The three species of cormorant of the Peruvian coast are, as will be seen, conspicuously distinct in plumage and in habit. The members of each species are numerous, but only one is of great significance economically. This is the "guanay" (*P. bougainvillei*), the most important guano producing bird of the coast. Strangely enough, this species is a less familiar one than either of the other two, although exceeding either of them in abundance. One may not visit a pier without hearing the grunts of the "cuervo de mar" (*P. vigua*); one may hardly take the shortest trip on the water without seeing the scarlet-footed "patillo" ("little duck," *P. gaimardi*) scurrying low over the water; but one may be ignorant of the most abundant species, unless by chance his boat pass near a cloud comprising perhaps hundreds of thousands of the "guanays," or, unless the solid black crest of some islet be pointed out as a rookery of "guanays."

PHALACROCORAX BOUGAINVILLEI (Lesson).

THE WHITE-BREAST CORMORANT, OR "GUANAY."

It need not be inferred from the previous remarks that the guanays occur invariably in enormous aggregations, for there are many relatively small rookeries. A flock of considerable size was noted at the Lobos de Tierra Islands, crowning an islet off the west side of the northern portion of the main island. A "loberia," or rookery of sea lions, bordered the lower portion of the island. Several birds were seen also at the Lobos de Afuera Islands, where no rookery was observed. Smaller rookeries were found at the Pachacamac Islands and Asia.

The preeminent home of the guanays, at least in 1907 and 1908, was the double group of islands off Pisco in the south, the Ballestas and the Chincha Islands (pls. 61 and 62). Each of the two island groups, which are only 5 nautical miles apart, comprises three principal units, those of Ballestas, the southerly group, being much smaller and much higher than the Chinchas. In each case we have

the "Isla de Sur," "Isla del Media," and "Isla del Norte." These islands are about 11 nautical miles from the port of Pisco, or about 4 and 9 miles, respectively, from the point of Paracas Peninsula. They are the most famous in the history of the guano industry; small as they are, and without a single permanent human habitation, the name of Chinchas is known to every seaport in the world.¹ Between 1850 and 1872 nearly 11,000,000 tons of guano are said to have been exported from these islands alone, and almost the entire deposit appears to have been of very high quality, with 13-14 per cent of nitrogen and about an equal proportion of phosphoric anhydride. The value of such a deposit at ordinary prices would be nearly three-quarters of a billion dollars, but the area of all the islands if combined into one would not be greater than that of a small-sized farm.

When the Ballestas were visited in May, 1907, each of the three islands had large flocks of cormorants, all of which, however, had been disturbed by the opening of the season for the extraction of guano. The smallest of the three flocks had occupied the southwest corner of the north island, beyond the bluff and on comparatively level ground. The main part of the rookery was bounded by nearly straight lines, being 85 meters in length, with an average width of 54 meters. The area was, therefore, approximately 4,600 square meters.

The south island of this group is some 300 feet in height and difficult of ascent. Its small top was nearly half covered with a compact rookery of between 10 and 12 thousand square meters. The area of the breeding ground on the middle island was only slightly less. In all, about 150,000 birds had nested at these islands during the preceding summer, for it was found that we could safely estimate the flock at about six breeding birds to the square meter.

At the Chincha Islands, visited in June, 1907, the guanays were using only the south island. But here was a rookery which for its size and compactness can scarcely be rivaled in any part of the world (pls. 61 and 62). Sixty thousand square meters of ground, or 15 acres, were closely covered with cormorant nests. It occupied about two-thirds of the surface of the island, embracing the crown and the gentle slopes of the hill surmounting the island. The nests were very uniformly spaced, about three to the square meter, and not an available meter of ground within the outside limits of the rookery was unoccupied. In one place 39 nests were counted in 12 square meters; in another, 52 nests in 18 square meters; in a third place, 33 nests to 9 square meters. These places were not more crowded than any other points within the limit of the rookery, the

¹ No less than 346 vessels are said to have embarked guano at the Chinchas Islands in 1858 (p. 205 of "Derrotero," previously cited, p. 453.)

spacing of the nests (as shown in pl. 63, fig. 2) being practically invariable and determined apparently by the minimum space requirements of a pair of breeding birds. One may safely compute the number of breeding adults by multiplying by 6 the number of square meters covered by the aggregation.

At this time, the close of the breeding season, the immature but grown nestlings were still being fed by the parents from mouth to mouth and occupied the parental nest. Estimating on the basis of two birds to the nest and three nests to the square meter, there would be 360,000 parent birds in the flock, with undoubtedly an equal or greater number of immature birds able to fly, about three-quarters of a million birds in all.¹ I had the opportunity to revisit this island briefly in the following month of July to find the flock at least 50 per cent larger, practically the entire island being occupied. The increase in size of the flock in this brief time may have been due in part to the accession of birds from the Ballestas Islands, but undoubtedly in part a natural expansion, as the older birds of the past season's brood mated and established homes of their own.

The photograph shows the form and arrangement of the nests on the hillside (pl. 63, fig. 2). The nests are rather less regular in distribution than at first appears. Whatever may have been the origin of the nests, they were now composed entirely of guano except for the little gravel or stone which was mixed with the guano. Each nest is like a shallow basin with heavy rolled rim, the diameter of the hollow of the basin being 20 cm. (8 inches) and that of the circumference of the rim 40 cm. (16 inches); the raised ring of guano surrounding the hollow is then about 4 inches wide. The nests, however, are not separate, but are portions of the continuous carpet of guano. The distance from center to center of nests varies from 50 to 70 cm., being generally a little less than 60 cm.

The young birds in the early days of June, although able to fly from the island with the older birds, were continually seen to be nagging the parents for food, pecking at them and expanding the throat to form a receptive pouch. When the food is conveyed the head of the young disappears entirely down the long throat of the parent and the two bend over to one side or the other, the brother young bird meantime making every effort to interfere and displace the more fortunate nestling. Even at this time there were among mature birds suggestions of preliminary love plays in the raising and lowering of crests and the brushing together of the birds of a pair. It was several weeks later when this island was revisited (in

¹ I am aware that others have estimated the number of cormorants at this island at much higher figures—up to 10,000,000; in the absence, however, of precise data regarding the method of computation employed, such estimates are to be viewed with conservatism at least.

July) and many eggs and even a few young nestlings were found. It is evident, therefore, that there is scarcely a "closed season" for parental responsibilities in this species.

Occasionally a wanderer bird is seen to be driven relentlessly from place to place as it works its way through the crowd. What was the significance of this I could not detect; whether it was a bird away from the proper nest or one without a mate, its unwelcomeness was unmistakable.

It is the habit of the guanays to remain on the islands the greater part of the time. They appear to leave only in search of food. They form, indeed, a great "breeding class." They walk more than either of the other Peruvian species of cormorant and their erect position and waddling gait is quite suggestive of the penguin. At a casual glance the birds in the photograph (pl. 61) might easily be mistaken for penguins.

Unlike pelicans, the guanays will return to some extent to rookeries whence they have been disturbed during the preceding season, although a preference for undisturbed islands was most clearly indicated by the growth of the flock on the South Chincha Island. When I revisited the island in 1908, a considerable number of guanays were still using the Ballestas islands, although the rookery was entirely broken up in the preceding year.

When one approaches a rookery the guanays crowd away with much grumbling, and when once a few birds arise in flight, the movement is liable to spread through the entire flock until hundreds of thousands are on the wing, even most of those that were too remote from the intruder to know the cause of the disturbance. It was found with these, as with other birds, that, if one waits motionless and with much patience, the birds will after a while return to the nests and gradually close around the observer, until at last only a circle with radius of 3 or 4 feet is left vacant. While in every direction one is surrounded by acres of birds all of a single species, the scene is yet peculiarly variegated. In one direction the birds are turned watchfully toward the intruder, and the thousand white breasts make a glistening white groundwork spotted with black heads; in another direction the birds are turned in side view so that the breasts show only as white streaks. Additional effects are caused according as the birds are more or less compactly grouped. Close around one, the metallic green heads, the green-lustred backs, sides and legs, the white throats, breasts, and bellies, and the hundreds of intent green eyes are most conspicuous. The voice of a single bird is a sort of a croak, less deep, less hoarse, and less powerful than that of a bullfrog, but somewhat of that character. The collective voice of the flock of hundreds of thousands is indescribable except as it

may be suggestive of the sullen mutterings of a disgruntled mob of human beings.¹

When the guanays leave the island in search of food they appear as a long black cloud several miles in length, streaming low over the water until they settle down to form a large black blotch on the surface of the sea. As a flock in flight rises on approaching an island it may be seen that the birds do not form an indeterminate mass, but are distributed in lines that bend and sway, ascending, descending, or swerving from side to side. The position of these varying curves at any moment could be reproduced by a drawing or a photograph; but the pleasing effect of the wave-like movement of the lines intersecting each other at ever-varying angles is impossible of representation.

The guanays are afflicted with parasites, but to a far less extent than the pelicans. One of the parasitic insects is said to inflict a very pernicious bite on human beings.

The economic importance of the guanay will be discussed after treating the other species of cormorants of the Peruvian coast. (See p. 482.)

PHALACROCORAX VIGUA (Vieillot).

THE BLACK CORMORANT OR "CUERVO DE MAR."

The "cuervo de mar" ("sea crow") is the common cormorant of the docks and piers of the coast as well as of the inland waters. They are rarely seen in long flight, but are almost invariably observed close to the shore swimming on the water or diving from low perches. They are generally in comparatively small groups, not exceeding a few hundreds in number.

In appearance this is the least attractive of the cormorants. Its general color above and below is dark brown, the back and belly showing some dark green. The naked parts are dusky black, except for the yellowish skin at base of jaws and chin. The large pouch-like throat enables them to swallow comparatively large fish, but gives them a coarse appearance. A long crest on the lower half or two-thirds of the neck can be raised like the bristles on a hog's back. The voice is a hoarse grunt. Walking over the long pier at Pisco for the first time persons not infrequently suppose that pigs are in some way penned below the pier, being misled by the grunts of hundreds of cormorants resting on the iron tie-rods and braces below.

The cuervos dwell little on the islands. At the Chinchas and Ballestas opposite Pisco, a few are commonly seen perched in line on the

¹ These notes regarding the voice of the guanays, individually or collectively, are transcribed verbatim from my field notes made in 1907. Forbes (1913) derived a strikingly similar impression. He says: "At times the noise is just like the sigh of the sea and at others it resembles the sound of a great crowd, all the members of which are talking at once." Additional notes of interest regarding this cormorant are comprised in his paper, cited as follows: [Forbes, H. O.] The Peruvian guano islands. The Ibis, ser. 10, vol. 1, Oct. 6, 1913, pp. 709-712. (Under "Notes and Discussion.")

slanting aerial trolley wires or on the low rocks near the shore. They remain generally motionless, though grunting noisily, but occasionally fly down into the water to dive for fish. They seem to prefer the bottom fish or shallow-water fish close in shore, such as the "trambollos" (blennies), which one may see from the rocks in almost any suitable place. The cuervo can swallow fish of considerable size, and I have found in the stomachs trambollo fish from $2\frac{1}{2}$ to about 10 inches in length.

The nesting places were observed only at the Lobos de Tierra Islands in the north in midsummer—December, 1907. It is not doubted, however, that a visit to the southern islands at the same season would have revealed nesting places in that locality. The choice of nesting site is characteristic and is well shown in the illustration (pl. 64). They were using small rough-topped rocks lying close along the shore, but partly or entirely cut off from the shore proper.

The nests contained from one to five eggs or young, usually four eggs or four young birds. The eggs are comparatively small and pale blue in color, the blue somewhat obscured by a chalky coating which is not uniformly disposed. They were variable in shape. Four eggs from one nest were of an ordinary oval form, 53 by 36 mm., and these were representative of most of the eggs observed; one nest, however, contained five greatly elongated eggs. The nestlings were black.

Dimensions, in millimeters, of the eggs of the "Cuervo de Mar."

	Long diameter.	Transverse diameter.		Long diameter.	Transverse diameter.
1.....	52	35	5.....	60	34
2.....	54	36	6.....	62	35
3.....	53	36	7.....	60	35
4.....	53	36	8.....	60	35
			9.....	61	34

Characteristic form.

Unusual form; 5 eggs from one nest.

As compared with the guanay, the tail of the cuervo is rather long, the bill rather short, and the bird is lighter in build. Its weight, about $3\frac{1}{4}$ pounds, is a fourth less than that of the guanay. The iris is green in both species.

The cuervo ranges probably the entire length of the Peruvian coast from Tumbes in the north to Chile, and it extends to the inland waters.

The cuervo de mar is excellently described by Taczanowski.¹ It must be remarked that in the specimens from which my color notes were made (Lobos de Afuera, November and December, 1907), the white feathers on each side of the auricular region, as described by

¹ Ornithologie, vol. 3, pp. 429, 430.

Taczanowski, were wanting. These white marks were noted, however, in examples observed at Pisco in June, 1907.

PHALACROCORAX GAIMARDI (Garnot).

THE SCARLET-FOOT CORMORANT OR "PATILLO."

The patillo, *P. gaimardi*, though less familiar to the landsmen, is a not less common cormorant than the preceding. To anyone navigating in small boats along shore or among the islands the patillo is a familiar feature of the seascape. One meets them floating lazily yet watchfully on the water, occasionally flapping wings or ducking beneath the surface as enjoying a bath, or making a sudden dive for prey to come up with a fish or a wriggling eel, which is swallowed only after a little struggle. They seem to be peculiarly successful eel catchers, as I have many times seen them with such prey. This species bears many local names. Among them are "pato de mar" (sea duck), "chuita," and "chiquitoy"; besides that of "patillo" (little duck).

Their flight is characteristic—low and straight. The appearance of intentness in flight is accentuated by the series of three conspicuous streaks in series; the orange and red bill, the white neck stripe, and the scarlet legs and feet lying straight back beneath the tail. The whole manner is that of one with predetermined course eagerly seeking a certain destination. I never saw one turn its head aside, as the swift gannet will do to investigate an observer. A very slight bend of the neck is sufficient for reconnoissance or for determining a change of course. Their short wings make flight a more strenuous and absorbing affair than for the gannet. Thus, as I have counted them, the wing strokes of the patillo, a minute, are from 250 to 300, as against 160 to 170 for the gannet, 150 to 190 for gulls of different species, and 140 to 150 for the pelican.

The home of the patillo is on the bold cliffs (pl. 65) and in the caverns, and the body color would give effective concealment against the rocky walls except for the brighter markings of the legs and the neck of the adults. As one approaches an apparently bare rocky wall rising above the surf, small bright red spots in pairs with three or four rays may be distinguished against the gray background of the rocks. If low down, they may easily be mistaken for star-fishes or the red-legged crabs left by the tide, but these are the legs and feet of the patillo. When one is a little closer a white spot is made out some distance above the red. The eye and the imagination may then fill out the form of the bird between the white neck stripes and the scarlet feet. The young birds against a rocky wall are almost indistinguishable even when one knows the exact location of the nest (pl. 65, fig. 2). When in flight, the bright skin colors and the neck

stripe, together with the characteristic manner of flight, makes this bird most easily recognized even at a great distance.

A surprising characteristic of the patillo is its cry, which is entirely unlike that of the ordinary cormorants that utter a coarse grunt or croak. When flying from the nest it often gives a high-pitched repeated chirp, somewhat like the note of the sparrow. This undoubtedly accounts for the common name sometimes used, "chuita," a name certainly more suggestive of a peewee than of a cormorant.

The nests are always isolated. Those examined were composed of a great variety of seaweeds, of many leathery worm tubes, of straw, feathers, and string, apparently any accessible and suitable material (pl. 65, fig. 1). One nest was weighed, although, unfortunately, more than a third of the material had been lost in removing it from the side of the cliff. The amount saved was found to weigh 8 pounds, and the complete nest must have weighed over 12 pounds. It was composed of *Ulva* and of various brown and red seaweeds, but the bulk of the total material was a chocolate brown weed with white tips, probably *Corallina chilensis*. The worm tubes, however, formed a very considerable portion, constituting $2\frac{3}{4}$ pounds or one-third of the material saved. These tough tubes, which bind together the looser materials to give strength and stability to the nest, must be of great value to birds that build, as the patillos do, such large and strong nests on almost any sort of a cliff where there is a bare foothold for the bird and the scantiest basis of support for the nest. Such tubes are, of course, taken only by diving, since the coast is free of exposed tidal flats.

The nests are frequently formed also deep in the caverns that undermine the walls of islands or mainland. The nests were found to have two or three eggs, but I did not happen to observe a nest with more than two young birds. The eggs are of very elongate oval form, pale blue, but smeared with a white coating unevenly distributed. Two eggs measured were respectively 6.3 cm by 3.8 cm, and 6.4 cm by 3.9 cm.

Tschudi¹ remarks on peculiarities of the coloration of the eye in this species, stating that the pupil of the eye of the patillo is sea green. I did not observe this, but my notes direct attention to the bright blue beading on the eyelids, 16 blue beads in all surrounding the eye.

The patillo (*P. gaimardi*), does not appear to extend very far north of Callao. It was never observed at the Lobos Islands of the north; in that region the *P. bougainvillei* is locally known as the "patillo." The name, "chiquitoy," applied in some localities to the

¹ On p. 314 of the Ornithologie, previously cited.

gaimardi, refers, I take it, to its small size among the cormorants. This cormorant has no appreciable economic value.

The three species of cormorants above described offer a striking illustration of the adaptability of nature. Three birds closely related, within the same genus in fact, dwelling in the same localities and not differing greatly in size, afford such striking contrasts in habits and appearance, as may be expressed in the following analysis.

Social habit.—The one herds in enormous flocks, another forms small groups, while the third is never seen except singly or in pairs. Of the two extremes, the patillo is always thought of as an individual, even though chance might bring several birds together, but the individuality of the guanay is always lost in the multitude.

Breeding habit.—The one nests crudely on the broad expanses of the island tops, another on the rough outlying rocks, while the third finds isolated homes on the cliffs or in the caverns where it constructs strong and secure nests of variously collected materials.

Feeding habit.—The one flies out in great flocks to swim on the surface and dive for prey in the schools of surface fishes; another watches from its low perches or dives down to capture the fishes of the bottoms near shore; while the third often makes long single flights before diving in search of eels or other fish or for nest-building materials.

Voice.—The one utters a distinctive croak, the second makes a harsh guttural grunt, while the third has a high-pitched voice of the timbre of a song bird.

Color.—The guanay has a shiny black back and glossy white breast, the cuervo is dark and of almost uniform coloring, and the patillo is of generally variegated color with white stripes and scarlet feet.

The patillo (*P. gaimardi*) is rather remarkable among cormorants for the entire absence of any disposition to gregariousness, and it is the most specialized of the three in its well-developed habit of nest construction and its instinct of protection of young, shown in the choice of location for the home.

All of the Peruvian cormorants are smaller than the American *carbo*, but the guanay and the cuervo are about equal in size to the double-crested cormorant, the patillo being much smaller. The long bill of the guanay nearly equals that of *Phalacrocorax carbo*.

Specimens of the "patillo" weighed 2 7/8 to 3 1/8 pounds. The "cuervo" weighs 3 1/8 to 3 1/4 pounds, while the guanay has a weight of 4 1/2 pounds.

ECONOMIC IMPORTANCE OF THE CORMORANT.

The guanay (*Phalacrocorax bougainvillei*) is the only one of the cormorants having especial economic value, but this one outranks all the other birds of the coast in significance as a guano producer.

It well deserves the name by which it has probably been known since prehistoric times: "the guano bird" or *guanay*. Its gregarious habit, its choice of the level places or more gentle slopes on the tops of the islands for a nesting place, and its custom of remaining on the island a great part of the time, lead to the formation of enormous deposits with very little waste. In the light of the evident adaptation of this bird by its habits for the production of large deposits of guano, and in view of the significance of its native Peruvian name of *guanay* it is difficult to understand how the chief importance could have been ascribed to any other bird. Nevertheless, the principal credit has been variously assigned by previous observers to other species such as the piquero (gannet) and the penguin.

The guano of guanays is also found to have a very high value in nitrogen compounds, but whether this is due to the particular character of its food or to other conditions can not be stated. As far as my observations go, the guanay feeds almost exclusively on the anchobetas or other surface-swimming fishes. In the region where this bird was most abundant, that of the Chinchas and Ballestas, the climatic conditions were most favorable for the preservation of the nitrates. Even though my visits were made during the winter season—May, June, and July, when the season of *garua* (a sort of fog) was prevailing on the coast generally—the atmosphere on these islands was invariably clear and dry. It is doubtful if the guano of the Chincha and Ballestas Islands is ever wet from atmospheric moisture. Consequently the nitrates are not converted into ammonia, to be lost by evaporation or seepage.

Fourteen to seventeen per cent of nitrogen, or more, may regularly be found in the comparatively new guano, and there are many analyses of record to show that even the old buried guano of past centuries, when mined from these islands some years ago, yielded as high as 12 to 14 per cent, indicating practically perfect preservation. A sample of new guano which I took in June, 1907, yielded 17.65 per cent nitrogen when analyzed in September at the sugar experiment station near Lima, through the courtesy of Mr. T. F. Sedgewick. A second sample from the same place kept in Callao, and analyzed in the following April by Mr. H. H. Bunting, showed 15.91 per cent nitrogen, while a third portion brought to the United States and analyzed in March, 1909, by the United States Bureau of Chemistry, contained only 8 per cent nitrogen—showing the marked deterioration from the effect of atmospheric conditions. Generally, as the nitrogen is lost in guano, the relative proportion of phosphatic compounds increases, but this means great loss in value, since phosphatic guanos have little value in comparison with nitrogenous or characteristically "Peruvian" guano. It is due to the rarest climatic conditions that the millions of tons of guano deposited during the previous times should have retained its nitrogen.

One may easily appreciate what enormous value such flocks of birds may have. A single ounce of permanent guano for each bird deposited each day, with a flock averaging 500,000 birds, would represent $15\frac{1}{2}$ tons of guano a day, or 5,700 tons a year. During the period of my stay in Peru the south island of the Chinchas was kept permanently "closed." No guano extraction was allowed by the Government, and the birds were undisturbed; this island was visited after one, and again after two years of closure. On the occasion of the latter visit it was estimated that between 12,000 and 15,000 tons had accumulated, and it was confidently predicted that at the expiration of the third year the recent deposit would amount to not less than 20,000 tons. These estimates were based on measurements of the thickness and the area of the deposits. Twenty-six measurements of thickness after 20 months closure showed an average depth of 18.5 cm., or 7.4 inches, indicating an annual deposit of 11.1 cm., or $4\frac{1}{2}$ inches, the weight of which would be about 300 pounds a square meter. Meantime, however, owing to the fortunate protection extended the birds by the enforced closure, the flock seemed to gain steadily in size. After closure for three years and four months, from November, 1906, to March 1, 1910, the island was reopened, and the published report¹ shows that 23,512 toneladas were taken from that island by the *Compañía Administradora del Guano* (22,337 English short tons, or 21,631 metric tons).

Guano of this high grade in nitrogen content rarely reaches the United States. For purposes of appraisal, however, it may be said that such guano, if purchased on the islands at \$40 a ton, brought to the United States, and sold at prewar prices, would have yielded a substantial profit after defraying all expenses. Consequently the value of the guano deposited by this single flock during a period of a little more than three years may be stated at nearly \$1,000,000. To quote from a previous report of mine:²

From the various calculations I have made it appears that a rookery will yield about 1 long ton of guano per year for 28 nests. Twenty-eight nests or 28 pairs of birds have an annual producing value of \$40 net. We give a fair idea of the commercial significance of these birds to Peru when we say that each brace of birds contributes annually \$1.43 worth of guano, besides leaving a pair of offspring to continue its service. Is it not, then, of the greatest importance that the fullest protection should be extended the birds, and every possible precaution taken to insure that there may be the maximum number of birds at every rookery, and that these birds may remain upon the rookery the maximum amount of time? [Page 359.]

Fowl which produce \$1.43 worth of guano a pair annually, without expense for care and feeding except the minimal cost of protection, may well be appraised at \$15 a pair. The fowl which dwelt on the South Chinha Island alone, when it was visited in 1907, might well

¹ *Compañía Administradora del Guano, Limitada. La memoria del directoria. Lima, 1910. [p. 21.]*

² The fisheries and the guano industry of Peru. *Bulletin of the Bureau of Fisheries for 1908, vol. 28. 1910. pp. 333-365.*

be regarded as an asset representing a value of several millions of dollars.

Nor is this the only flock, although the principal one of the coast. Other important flocks were noted at the Lobos de Tierra Islands of the North, at Asia, Pachacamac, and other places, besides the neighboring flocks at the Ballestas Islands, and on outlying rocks. There were four or five small islets about the North Chincha Island, each with something like 1,000 guanays. In 1907 the Ballestas North, Middle, and South Islands, respectively, yielded about 500, 800, and 900 tons of high-grade guano.

When first deposited the guano is wet and sloppy, but under the baking sun this forms a hard thick cake, in color gray, which can be broken with an axe or a pick. As the deposits of later years accumulate, the lower layers undergo a change, becoming finely pulverized, so that old buried guano can be scooped with a shovel. The old or mineral guano may be of various colors, red, brown, almost black, or light gray, or even green, due in part to chemical changes, in part to foreign substances mixed in. When exposed to the sun, the old guano sometimes acquires a thin crisp whitish crust. Walking over this may give the sound of walking on the icy crust of snow. The old guano does not, however, always bleach white.

Into the formation of such deposits go not only the excrement but all offal matter, such as waste food, dead bodies of young and old birds, and unhatched eggs—all may be finally blended into one apparently undifferentiated mass.

It is related that one of the islands of the Chincha group was reduced 100 feet in height by the extraction of the deep crown of guano deposited during past centuries. The story is by no means incredible, since, if the flocks of birds of the South Chincha Island could have remained undisturbed and continued breeding in the same place, the top of the island would certainly have been raised a hundred feet in about four centuries. The wonder is not how came the deposits of tens of millions of tons, but what became of the other millions which must have formed during past ages but which are not accounted for by the records of extraction. How much must have been lost by wasting into the sea!

There are given below the analyses of several samples of recent guano of guanays from the Ballestas Islands, showing an extremely high value in each case:

	Moisture.	Sand.	Organic matter.	Phosphoric acid.	Alkalies, etc.	Containing nitrogen.	Equal to ammonia.
1.....	20.26	0.75	56.59	8.89	13.51	15.91	19.32
2.....				12.35		17.65	
3.....	19.77	1.35	54.23	10.35		15.40	
4.....	19.95	2.20	54.10	10.36		14.95	
5.....	19.80	1.60	51.80	10.48		14.58	
6.....	18.20	3.60	51.15	11.19		14.41	
7.....	21	2.10	51	10.66		14.33	

These analyses were made for me, severally, by Mr. H. H. Bunting, F. C. S., Oficina de Ensayes of the Peruvian Corporation (Ltd.), in Callao, and by Señor P. G. Ureña, of the Estacion Experimental para Cana de Azucar, near Lima (through the courtesy of Mr. Thomas F. Sedgewick, director of the station).

THE PELICANS.

According to report, the pelicans are represented on the Peruvian coast by two species, but the common one and the only one that I observed was *Pelecanus thagus* Molina. It is one of the largest representatives of the pelican family, its measurements being distinctly greater than those of the American white pelican and much greater than those of the common American brown pelican. Taczanowski records *Pelecanus fuscus* Linnaeus as collected by Captain Markham at Payta. I have a copy of Taczanowski's "*Ornithologie*," formerly in the possession of Doctor Nation of Lima, in which is a penciled entry noting its occurrence at Lima.

PELECANUS THAGUS Molina.

THE PELICAN OR "ALCATRAZ."

The alcatraz is common on the entire Peruvian coast. I observed it from Tumbes in the north to Mollendo in the south. During the period of my stay on the coast it was present in much greater numbers in the northern region than in the south, but this was doubtless attributable to temporary conditions which, as will appear later, afforded the bird better protection for nesting on the larger islands of the north.¹

The description of the species as given by Molina, or by Taczanowski, need not be repeated here. There are, however, a variety of color phases to baffle the observer at first, as may in part appear from the photographs. Some of the color phases of the young are mentioned later. The typical coloring during the period of incubation (pls. 66 and 67 and pl. 68, fig. 2) comprises a white forehead and neck stripe, dark brown neck and back, upper sides of wings more or less variegated. The nuptial plumage, as I take it, preceding this stage is characterized by yellow in place of the white on head and neck. The older birds become more and more white, especially on the head and wings. Some are found that have the back and belly and neck gray, and the head all white (pl. 68, fig. 1) while birds that I presumed to be the oldest, were almost entirely white on back and

¹ I suspected that the pelicans of the southern portion of the coast of Peru had migrated to still more southerly latitudes. Captain Jefferson of the Chilean steamship line said to me in 1907 that vast numbers of pelicans were observed at islands along the coast of Chile in higher southern latitudes than he had been accustomed to see them.

wings, the belly being brownish and the head and neck all white.¹ A variety of color phases have been fully described by Forbes,² who does not attempt to interpret their sequence in life history.

Forbes, in the paper cited, gives an interesting account of the habits of the pelicans. The observations which I offer here are generally supplemental to his account.

Pelicans, whether breeding or not, spend a great deal of time on the islands and are commonly seen standing in solemn ranks on some hillside or on a point of land commanding the ocean. They are more timid than most of the other birds, so that one may not approach them readily. Particularly in the morning, they delight to find some quiet little cove where they bathe and splash in the water. They make long flights on the ocean, flying in long files with slow wing strokes. The comparatively slow movement of the large wings gives a false appearance of leisureliness to the flight, for it was observed that they were rarely passed by the more "swift-winged" birds of smaller size. They not infrequently float on the water while waiting for food or resting between meals. The pelican shows ease and grace of movement only in flight—the dive for fish has an appearance of awkwardness and causes a great splash. The bird does not appear to go under water, the heavy coat of feathers probably making this impossible. With its long neck and bill fish may, however, be reached several feet beneath the surface. They may devour even large fish; at one nest I found a regurgitated mullet or "liza" (*Mugil cephalus* Linneaus) over a foot in length. The anchobetas (*Engraulis ringens* Jenyns) con-

¹ The following is an account of the color changes as far as I could make them out, by inference from observation of the group, without the opportunity to trace the history of individual birds. With this qualifying statement, I give them for what they may be worth in suggestion to other observers.

(A) The immature bird after leaving the nest is brown with white breast, some buff on the upper side of wings. Head and neck brown and without lateral stripe. Bill green at base and top, sides orange. Pouch orange yellow (pl. 69).

(B) Nuptial plumage: The feathers of head and neck stripe are yellow; the "cravat," or necklace of yellow, is formed, while the rest of the neck is a very dark brown, almost black. The covering of striate feathers on the back and lower side develops, while the mantle of pearly gray completes the nuptial plumage. The pouch becomes black with blue stripes on the sides anteriorly and the characteristic red appears on the generally greenish bill. This phase was observed in birds occupying new-made nests and often in outlying rookeries. No adults of this phase were found on nests where the eggs had hatched out.

(C) After the beginning of the laying, the yellow feathers are shed and replaced by white, which, however, do not extend so far into the crest nor are so long as the yellow. A "cravat" of greater or less size may be retained or may be lost entirely. Many of the birds in the nests had heads partly yellow and partly white. The longer yellow feathers being in patches of greater or less size amid the shorter crop of whites. The changes do not always occur in just the same order. Thus whitehead birds may still show some white feathers in the lower side of body.

(D) Another phase may be described, but whether it represents a possible stage between (B) and (C), or an older stage than (C), or is a phase peculiar to one sex, I am unable to say. Birds in this phase were observed to be brooding. The head and neck stripes are light gray, the neck is soft gray, the upper parts are generally brown, but a small region of back and breast around the base of the neck has the typical white and dark brown striate feathers; the breast is generally white mottled with brown feathers having a white median stripe; the bill is red and yellow, the pouch as in (C) but paler. This phase includes some features of the immature (A), and some of the typical brooder (C), but the gray neck is characteristic.

² Forbes, Henry O. Notes on Molina's Pelican (*Pelecanus thagus*). The Ibis. Tenth Series. Vol. 2, No. 3. London, July, 1914, pp. 403-420.

stitute a considerable proportion of the food of pelicans as of the other sea fowl.

The nests are made on the level ground or on gentle slopes and generally in large aggregations (pl. 66). After the rookery at the Lobos de Afuera Island was broken up in 1907, many smaller rookeries were found in the following season (Dec., 1907), in addition to one or two that were some acres in extent. Some of these rookeries were connected in a curious rambling way (pl. 67). The nests are less regularly spaced than those of the guanays and naturally are much farther apart; while the guanays average 3 nests to the square meter, the pelican will average only about 2 to the square meter.

The behavior of pelicans on the nesting grounds in some respects appears stupid and inexplicable. An alcatraz on her nest will sometimes reach over with her long neck and bill, take a fledgling from the uncovered nest of a neighbor and throw it away, perhaps into another nest. Once, within a space of 2 square meters, I saw six little "pichones," almost new born, bandied about in a most merciless way, tossed from one alcatraz to another, each seemingly unwilling to have the little birds in their proximity. Finally three of the fledglings were thrown beyond the margin of the nesting ground and left to die in the sun. I watched a pelican that returned to a nest from which the only fledgling had been transferred by a mischievous neighbor into an adjoining nest. The returning brooder did not appear to notice the loss, but sat composedly on the remaining egg; then, pilfering on her own account, she quietly reached over and stole all of the feathers from the nest in which lay her own offspring (supposedly) among others, to add to the lining of her nest. I questioned if the birds invariably occupied the same nest; on one occasion, at least, a bird was seen to brood on two different nests. The birds near the margin had been frightened away, but, most of them returning, all of the nests were soon reoccupied except the ones nearest to me. An alcatraz, after sitting for 15 minutes on one nest, moved slowly over to another nearer to me, while its place on the first nest was at once taken by a bird that was previously covering an empty nest. The young were trampled dangerously by the old birds as they moved awkwardly about. Perhaps these are abnormal actions, attributable to nervousness caused by the presence of an intruder.

I never found any considerable number of nests uncovered but once, when I came on a small rookery of some 100 to 200 nests, where there were only a dozen birds. Returning after an hour or less I found the same condition. Supposing the ground abandoned, I opened some eggs from different nests, finding live embryos in all. The eggs remained warm under the midday sun. Doubtless the insect parasites which swarm on the nesting grounds would occa-

sionally compel the brooding birds to seek the shores to rid themselves of the pests, as far as possible, by splashing in the water.

Birds are often seen coming to the nests with feathers between the jaws, or with pouch hanging low with small feathers or trash, which is ejected with some difficulty and deposited by the side of the mate to add to the lining of the nest.

The nests, as observed, were shallow and roughly lined with feathers and usually contained many small rocks. They contain a variable number of eggs—from 1 to 8; 3 is the most common number. Of 207 nests counted 35 contained 1 egg; 73 contained 2 eggs; 84 contained 3 eggs; 10 contained 4 eggs; 4 contained 5 eggs; 1 contained 6 eggs.

Most of these were not new nests, so that the number of eggs was probably permanent, barring accident or intrusion. In looking over a large number of nests I saw two with 8 eggs each; from one of these the eggs were opened and all contained live embryos of approximately the same size. A number of nests with 6 eggs were seen, while 5 was a very common number. Four nests, each with 1 egg apparently old, were marked; 6 days later, they were as at first. Three nests, each with 1 white (new-laid) egg, were marked (Nov. 29); 2 days later they were unchanged, but after 6 days one had 3, another still one, and the third was empty. Of 7 other nests marked, one with 2 white eggs gained 1, while 1 with 3 eggs lost all. Loss of eggs may occur from the depredations of the gulls or gallinazos (turkey vultures); from the awkwardness of the parents causing eggs to be thrown from the nest when the birds start in flight; and, doubtless too, from pilfering by stray cats that, unfortunately, infest the island.

The eggs when new-laid are pure white in color, but soon become so soiled with guano as not to appear white at all. The form is variable, and the ends are sometimes almost equal. The size is about 82 mm. in length by 56 in transverse diameter and a little less than 5 ounces in weight. The length of 10 taken at random was from 76 to 97 mm.; transverse diameter, from 53 to 62; weight, 4 to 7 ounces, as shown by the following table. The egg of 97 mm. in length and weight 7 ounces was a very exceptional one.

Dimensions and weight of 10 eggs of Pelecanus thagus, Lobos de Afuera.

Specimen.	Length.	Transverse diameter.	Weight.	Specimen.	Length.	Transverse diameter.	Weight.
	<i>Milli-meters.</i>	<i>Milli-meters.</i>	<i>Ounces.</i>		<i>Milli-meters.</i>	<i>Milli-meters.</i>	<i>Ounces.</i>
1.....	82	55	4.5	6.....	80	55	4.5
2.....	80	55	5.0	7.....	78	56	4.5
3.....	79	55	5.0	8.....	97	62	7
4.....	86	58	5.5	9.....	76	55	4
5.....	80	53	4.0	10.....	78	58	4.5

The average of these measurements is 79.9 by 55.6. Forbes found an average of 83.7 by 55.7.

The young birds are bare of feathers, and, as I observed them at the Lobos islands, with black, dark blue or purple skins, but Forbes says¹ they "are of a pale flesh-color, thus differing markedly from those of the brown pelican (*P. fuscus*) which, according to Chapman, are livid black." They are of some size before the white downy covering is acquired. The birds are nearly full grown before the first feathering appears on the wings and back. (See pl. 68, fig. 2, showing an old bird and young in several stages.) The young about this time seem to be substantially larger than the adults in almost all dimensions.² A young bird just attaining the stage of flight from the nest is shown in the illustrations (on plate 69). The very dark brown or fuscous coloring of head, neck, back, and sides is conspicuous. The rump is lighter in color while the belly is nearly white. There is yet no sign of the white forehead and neck stripe of the adult. This bird was kept as a pet for several weeks.

The season of nesting is almost uninterrupted, though less active during the winter months of May to September. In March and April, 1907, the rookeries at Lobos de Afuera contained thousands of eggs and young in all stages. On June 18 of the same year, young nestlings just beginning to feather were observed on an islet near the North Chincha Island. The Lobos de Afuera islands were again visited in December, when the large rookeries were filled with eggs and very young nestlings.

In the south the only active rookeries noted were on two islets near the North Chincha Island; although numerous evidences of abandoned pelican rookeries were observed on various islands of the Chincha and Ballestas groups, on San Gallan, and on the Santa Rosa Islands at the Bay of Independencia. At the latter place, I was informed by a fisherman that, a few years before, a guano extractor, finding the young pelicans in the way, had herded them and driven them over the cliff. Examinations of the beach at the base of the cliff revealed thousands of skeletons of young pelicans with other débris.

In the autumn of 1907 (March), at Lobos de Afuera, a rookery many acres in extent (pl. 63, fig. 1) occupied the northern point of the eastward island, and a small islet to the north of it. It was estimated that there were about 100,000 birds. During the following winter this was entirely broken up by the extraction of guano. At the beginning of the next summer (December) there were numerous (six or more) small rookeries scattered over this island and containing in all about 2,000 nests;

¹Forbes, Henry O. Notes on Molina's Pelican (*Pelecanus thagus*). The Ibis, ser. 10, vol. 2, No. 3, London, July, 1914, pp. 403-420 [p. 416].

²The grown young are normally somewhat heavier. Several fully mature pelicans weighed 12-14 pounds, a very old and thin bird weighing only 9½ pounds. A young specimen had a weight of 16 pounds.

but the majority of the birds were occupying the westward island, which had not been disturbed. Here, too, were many scattered rookeries, some with birds in small groups, others with nests arranged in long rambling ranks (pl. 67). At the end of the land, however, and connected with the last-mentioned series, there was a large rookery including probably 6,000 nests (pl. 66). It was estimated that there were between 10,000 and 20,000 nests on the group of islands. A great many of the birds had apparently removed to the Lobos de Tierra Islands, a few miles to the north.

The change of conditions noted in successive seasons on the Lobos Islands as regards the nesting of pelicans, was only one of many evidences that this species is not easily reconciled to disturbances. The adult pelican will often stand by its young, but the radical disturbance of its nesting ground, as by removal of the guano, seems to be the signal for a change of location in the following season. The pelican is, indeed, relatively timid and clannish by nature. Its nesting grounds were never observed in close proximity to those of other birds.¹ It was noted also that the rookeries were generally well removed from the loberias (or rookeries of sea lions), though this may have been due to chance.

Pelicans are more infested with insect pests than any other of the guano birds. The neighborhood of the nests is, therefore, a most unpleasant place to stand for any length of time. One of these (a Mallophaga?) is abundant all over the ground; it crawls up the legs, body, and neck of the bird to find an attachment within the pouch, where it may always be seen in scores. The great bills are quite helpless against such pests, and the only defense seems to be in the daily baths which the pelicans take in convenient coves.

Other enemies of the pelicans are the gulls and "gallinazos," whose depredations will be described in the account of the gallinazos (p. 498). Cats undoubtedly prey upon the young. It is interesting that cats, which have escaped from the guano workers' or fishermen's camps should have established themselves upon the Lobos Islands, where there is no possible source of fresh water, although an abundance of bird and fish food is to be found in the rookeries and on the beaches. The extermination of these cats is strongly to be recommended, and the conveyance of cats to the islands should be prohibited.

Still another enemy of the pelican is the abundant "lobo," or sea lion, although I can not rate highly the damage done by it. I wit-

¹ On the other hand, Forbes, from observations at the Chincha Islands when pelicans and cormorants had just returned after a remarkable and unexplained absence of a year, found the nesting pelicans "crowded together in large colonies, very generally surrounded by still denser and more extensive colonies of *Phalacrocorax bougainvillei*." He adds: "At this season the birds are extremely timid and rarely allow the near approach of an intruder without taking wing with a reerminating 'wauk' from their nest; in this respect they are unlike their incubating friendly neighbors, the cormorants, which allow one to come comparatively close to them without leaving the nest." (Forbes, *The Ibis*, vol. 2, 1914, p. 415).

nessed the successful capture of a pelican by a sea lion, as is elsewhere described, and, at another time, found the floating body of a pelican which had evidently been destroyed in the same way. Such mutilated bodies are said to be found occasionally on the beaches. However, unless a pelican were hampered by previous injury or weakness, it is not often that a "lobo" could make a successful capture. A young pelican which I kept in confinement was sometimes allowed to swim in the water when large sharks were near. It was very successful in detecting the approach of a shark, and would fly from place to place as far as the line permitted, while followed by the shark. The fear of the animal was probably founded upon a real danger, but at the same time served to protect the bird from actual capture. It was observed that when a school of anchobetas appeared, breaking the surface of the water for acres, the pelicans and gannets would not always plunge into it at once, but would first circle about for several minutes, and it was presumed that this was done in order to reconnoiter for the detection of dangerous enemies. The question of the damage done by the lobos is of especial interest, since the extermination of these forms has been suggested. All the evidence and many observations in relation to this question have been fully discussed in a previous report where it was recommended that the sea lion be utilized as an asset, but not treated as a subject for extermination.

The chief enemy of the pelican in modern times is man. Many birds have been killed for the feathers, of which the pelican possesses a very thick coat. At Pacasmayo I was told on reliable authority that many fishermen and guano laborers went out to the islands with straw mattresses and returned with feather beds. The eggs of guano birds have in past times been taken in vast numbers partly for food, but more especially for the use of the albumen in the clarifying of wines. Such ruthless destruction is forbidden by the Government, and has been practically stopped. However, about 1907, a boat that was captured by a Government cutter, was found to be carrying nearly 20,000 eggs.

The serious decline of the pelican flocks is, I am sure, to be attributed more particularly to the disturbance of the rookeries in the extraction of guano, as will be discussed below in the consideration of the economic significance of the pelicans as producers of commercial guano.

ECONOMIC IMPORTANCE OF THE PELICAN,

The pelican is actually one of the two most important guano birds of the coast, but its value is undoubtedly far less at the present time than in the past. Two considerations should be kept in mind. The importance of the guano production depends not only upon the abundance of the birds, but also in great part upon the latitude of the islands selected as breeding grounds. The latter consideration has not been

given adequate consideration in connection with the protection of birds. As previously indicated, ideal conditions prevail in the region of the Chincha Islands, but not to a like extent in the north. Rain, indeed, is very rare on the Lobos Islands,¹ but the humidity there is much higher, so that a considerable proportion of the nitrogen of the guano escapes in the form of ammonia. Consequently no Lobos Island guano is of the high quality of the Chincha guano, and this difference is not due solely to the difference of the species of birds acting as chief producers. As a matter of fact, the freshly made guano of the pelican may be very high in nitrogen. Analysis of pelican guano, taken from a cage in which I kept a pelican, and bottled the same day as deposited (but after allowing to dry), showed a nitrogen content of 21.66, with phosphoric acid in amount 4.30; while a sample taken from the surface of the rookery on the same island (Lobos de Afuera) analyzed only 8.41 nitrogen and 17.40 phosphoric acid. Comparison of guano cake from the rookery of guanays in the Chincha region shows 15.91 per cent of nitrogen and 8.89 per cent phosphoric acid.² Of course it is primarily the nitrogen that determines the value of this fertilizer. The difference in percentages of nitrogen in the cage and rookery guanays is not to be attributed solely to atmospheric conditions, but is accounted for partly by the foreign materials which pelicans introduce on the nesting grounds in much greater degree than do the guanays, all of which add to the bulk with less proportionate addition to the value of the guano. The complete analyses show, however, that the fresh unmixed pelican guano and the guanay rookery guano (Ballestas Islands) have nitrogen constituting more than a fourth of the organic matter (26 and 28 per cent, respectively), while the guano from the pelican rookery (Lobos de Afuera) shows nitrogen as less than one-fifth of the organic matter (19 per cent).

¹ That rain has occurred on the Lobos de Tierra Islands was evidenced by the signs of comparatively recent erosion. Some very distinct, though small, water channels were noticed on some of the hills. I was told by the fishermen that a light rain had fallen two years previously.

² The complete analyses are as follows:

	Pure guano of pelicans from cage.	Guano of pelicans from rookery, Lobos de Afuera.	Guano of guanay from rookery, Ballestas Islands.
Moisture.....	9.40	16.14	20.26
Sand.....	.85	9.10	.75
Organic matter (a).....	81.75	43.86	58.59
Phosphoric acid (b).....	4.30	17.40	8.89
Alkalies, etc.....	3.70	13.50	13.51
	100.00	100.00	100.00
(a) Containing nitrogen.....	21.66	8.41	15.91
Equal to ammonia.....	26.30	10.21	19.32
(b) Equal to tricalcic phosphate.....	9.38	37.98	19.41

The fact is that guano of the Chincha region is richer than guano from the Lobos Islands when extracted. Paraphrasing a good proverb, and speaking from the commercial point of view, a pelican in the south is worth two in the north.

The southern climatic conditions are believed to be adapted to the pelican equally as well as the condition in the north. The preference of the pelicans for the Lobos Islands at the period of my visit is easily susceptible of explanation. As long as guano extraction is carried on regularly on all of the islands, with consequent disturbance of the breeding grounds, the pelicans will naturally confine themselves to the outlying rocks, or to the larger islands (such as the Lobos Islands), where it is possible to take up new ground at a distance from the scene of commercial work. It was a matter of observation that the pelicans occupied a few outlying and rather inaccessible rocks near the Chincha Islands and the large Lobos Islands in the north, together with some outlying rocks in that region. There were, however, the most direct evidences that pelican rookeries had existed on the Chincha, Ballestas, and Santa Rosas Islands, as well as on San Gallan. Finally, there are entirely reliable statements that pelicans were formerly exceeding abundant in the Chincha region.

It was attempted to learn what amount of food the pelicans would consume in a day and what the daily production of guano was, but the experiments were not very satisfactory, owing to the fact that in confinement the birds would refuse to eat for several days. Each of two birds produced about half an ounce of guano in the first night of captivity. One of them, after fasting for six days, consumed 4 pounds of fish in one day, but later refused to eat and appeared so unwell that it was liberated. The experiment could probably be readily carried out with an immature but grown pelican.

On one island occupied by pelicans the deposit was 17 cm. thick at the thickest part, and I was told that the island had been left clean at the end of the preceding season. The islet covered about 1,225 square meters, but, as the guano was very thin in some places, the total yield was only about 125 tons. With a uniform thickness of 17 cm. such an area should have yielded a little more than 200 tons. The odor suggested a high nitrogen content.

THE MAN-O'-WAR BIRD OR "TIJERETA."

The common name, "tijereta" (meaning "scissors"), as applied by the Peruvians to the man-o'-war bird, *Fregata*, sp., is aptly descriptive of its sharply-forked tail which opens and closes in flight. It is scarcely a common bird of the region of the guano islands, having a more tropical habit. Nevertheless, they are not infrequently seen about the northern islands either soaring in lofty flight or descending to pursue the gulls or gannets. When the harassed

birds disgorge their prey in self-defense, the tijereta with swift flight will recapture it in mid-air or snatch it from the surface of the water. In one instance I have seen the table almost turned when a large gannet (*Sula nebouxi*) pursued a tijereta back and forth for a considerable time. A turn of the tijereta from time to time would put the gannet to temporary flight. The end of the combat was not witnessed.

Stolzmann, as quoted by Taczanowski,¹ says:

The Peruvian port of Payta is the southern limit of geographic distribution of this bird on the Pacific Ocean. It is astonishing that it is found on the Atlantic as far as Rio Janeiro, 23° S. latitude, while on the Pacific it does not pass the 5° of S. latitude.

Undoubtedly the colder waters of the west coast are not favorable to an extended range, but my records indicate a more southerly range than is stated by Stolzmann. The tijereta was observed at Tumbes (3½° S.) in January, 1908; at Paita (5° S.) in April, 1907; at Lobos de Tierra (6½° S.) same month; at Eten (7° S.) in November, 1907; and at Pacasmayo (7½° S.) in March, 1907. At Eten nine specimens at one time were seen in flight inland from the village, and a little later some six or seven more were observed. Only one example was noted at Pacasmayo, but a reliable local informant at that place spoke of it as an occasional visitor.

The mangrove-bordered estuaries of Tumbes in the far north of Peru undoubtedly constitute its most southerly nesting place. In January, 1908, their nests were seen in abundance on the mangrove trees, as had previously been described by Stolzmann.

Von Tschudi mentions the red-billed tropic bird, *Phaethon aethereus* Linnaeus, as occurring on the Peruvian coast and states that the Snakebird, *Anhinga (Plotus) anhinga* (Linnaeus), nests on the islands of the coast. The latter is mentioned as one of the important guano birds. Neither of these was observed on or near the islands.

THE SHORE BIRDS (LIMICOLAE).

While the Limicolae, or shore birds, are well represented in favorable regions on the mainland, they do not in any abundance frequent the Peruvian Islands with their generally rocky shores. The islands of Lobos de Afuera and especially Lobos de Tierra offer more favorable beaches than any of the others, although some of the shore birds may be met on almost any of the island groups. No extensive collections of birds of this order were made, but the species collected and identified are mentioned in the following paragraphs.

The oyster catcher or "brujillo de pecho blanco" (little witch with white breast), *Haematopus palliatus (brasilianus* Maximilian?), was recorded in my notes at the Chincha Islands, Chilca Bay, and the Isla Vieja. With its distinctive cry and striking color markings, the

¹ Ornithologie du Pérou, p. 428.

white-breast brujillo is unmistakable, whether in the air or on the land. In flight the conspicuous white band on the upper surface of the wing, the white breast, the almost black head, and bright red bill directed downward and continually opening and closing, makes this bird as conspicuous as does its shrill excited cry. While on the ground they usually make a single isolated call, but when flying high-pitched cries are uttered almost incessantly. On one occasion, in the little Bay of Chilca, about a dozen of these birds in a group on the shore, becoming excited from some cause, fairly filled the small amphitheater with their shrill voices. This was an unusual aggregation, for I rarely observed them except in pairs, whether at rest or in flight.

A female, taken at the Chincha Islands in June, had only very minute eggs in the ovary. In a female taken at Asia in the latter part of August the eggs were 3 to 4 millimeters in diameter. Stomach examinations revealed small pebbles, pieces of crustacea (*Hippa*, etc.), pieces of shell, opercula of gastropods, and mussel shells. A specimen taken at Chincha had a weight of $1\frac{3}{4}$ pounds.

The black oyster bird, or "brujillo" (*Haematopus quoyi* Brabourne and Chubb), was more commonly observed than the other. It was noted at the Chincha Islands, Chilca Bay, Asia Island, the Bay of Independencia, Paracas Bay, and Lobos de Tierra.

The curlew or "sarapico" *Numenius hudsonicus* (Latham), is not infrequent on the islands, and, of course, is quite commonly found on the mainland about small lakes or rivers. They frequent the available beaches of the islands, singly, in couples, or in small flocks, and at a little distance are barely distinguishable against the sandy beach. They have a high-pitched excited cry when flying. The stomach contents of two specimens examined were exclusively portions of *Hippa*, the common "mui-muis" of the sand beaches. In these examples the eggs were small, about 1 millimeter in diameter (Chincha Islands, June 14, 1907, and Chilca, Aug. 27, 1907).

The small beach birds, sandpipers, plovers, etc., were observed rather abundantly at Lobos de Tierra in December, 1910, and they were not uncommon at Lobos de Afuera about the same time. The following specimens were taken:

Arenaria interpres (Linnaeus), Asia Island, August 26, 1907.
Common name: "Til-Til."

Arenaria interpres (Linnaeus), Lobos de Afuera, December 3, 1907.
Common name: "Til-Til."

Heterosceclus incanus (Gmelin), Lobos de Tierra, December 13, 1907.
Common name: "Til-Til."

Calidris leucophea (Pallas), Lobos de Tierra, December 10, 1907.
Common name: "Til-Til blanco."

Aegialitis nivosa (Cassin), Paracas Bay, June 29, 1907. Common name: "Chinita."

Aegialitis nivosa (Cassin), Paracas Bay, June 29, 1907. Common name: "Cajero."

Ereunetes pusillus mauri Cabanis, Lobos de Tierra, December 13, 1907. Common name: "Til-Til."

THE CONDOR.

None of the vultures are significant guano producers, yet they are found on the islands, and at least one of the species is an important factor in the bionomics of the island.

The large condor, or "buitri" (*Vultur gryphus* Linnaeus), "the king of the vultures," is not uncommon in the higher hills and mountains of the interior of Peru and visits the coast to feed upon the animal matter cast up on the beaches (D'Orbigny).¹ It is reputed by the natives to prey sometimes upon the nestlings of guano birds, but such depredations were not observed. Individual birds, evidently of this species, were not infrequently seen resting on a hillside or on some high ledge of the islands south of Callao, as at Santa Rosa, San Gallan, the Ballestas Islands, and Isla Asia. Doubtless the condor frequents islands north of Callao; but my visits to islands of the northern region were principally to Lobos de Afuera and Lobos de Tierra, which are, respectively, 10 and 35 miles from the main shore. According to my native guides at these points the condor is never seen on these islands.

D'Orbigny states that the wing spread of this condor does not exceed 3 meters and that the ordinary length is above 1½ meters.

In this connection it may be mentioned that the true king vulture, *Sarcoramphus papa* (Linnaeus), which, according to D'Orbigny, is not half so common as the condor, and is confined to the eastern side of the Andes, has been recorded by Stolzmann from the west coast between Tumbes and Lechugal.²

Condors are undoubtedly becoming rare, while the vultures mentioned below increase with the spread of human habitation. The rapacious condors are pursued, while the harmless vultures are, in a measure, protected for their service as scavengers.

THE VULTURES OR "GALLINAZOS."

The "turkey vultures," or "turkey buzzards" ("gallinazos" they are called in Peru), are not only among the most common birds seen about the towns and villages, but are found on any island inhabited by other birds or by sea lions. The commoner species near the cities

¹ Taczanowski. Ornithologie du Pérou, vol. 1, p. 75ff.

² Idem, vol. 1, p. 81ff.

is the black vulture, "urubu," or "gallinazo de cabeza negra" ("gallinazo of the black head"), *Coragyps foetens*, which undoubtedly renders most useful service where the scavenger work is otherwise too little provided for. With them is found the red-headed gallinazo (*Cathartes aura*), which renders similar good service, but which is less numerous and, according to report, more timid in its nature.

The latter species is common on the islands, whither it is attracted by the excellent opportunities for feeding afforded not only on the beaches but on the rookeries of birds and of sea lions. On the islands, indeed, it is at least questionable whether its beneficial services as a scavenger outweigh the detriment that it works by its depredations upon the nests of the birds of more direct importance. The gallinazos are always to be seen about the loberias or homes of the sea lions, and in the rookeries of pelicans, gannets, and cormorants. Their diet is not restricted to refuse of the beach and dead bodies of birds and sea lions they may find occasionally on the higher ground; whenever the opportunity occurs they will snatch the eggs from the nests or devour even the young fledglings. Any visitor may make such observations, since the presence of an observer, causing the birds to fly temporarily from their nests, gives a most convenient opportunity for the gallinazos to commit their depredations. That they do not have to wait for such an unusual occurrence was shown by the repeated observation of two or more gallinazos or gaviotas working together to despoil the nest of a piquero; while the anxious parent is occupied in driving the intruders away, the other gallinazos or gaviotas seize the opportunity to rob the uncovered nest of eggs or nestlings. Perhaps this cooperative assault is not the result of definite plan, yet it seems quite clear that when the attack is initiated by one bird the others recognize that the result will bring a desired opportunity and prepare to avail themselves of it. At other times they snatch the opportunity to feed upon the fish brought by the parent to feed the young but for some reason prematurely disgorged; the offended bird contests with the intruder for the fish, but the latter is usually successful in getting a large share.

While the gallinazos render some service in the rookeries by consuming the waste food and the bodies of fowls which may die at the nest, yet in the dry atmosphere of the islands, where the sun shines every day, it is doubtful if such bodies would accomplish much injury. The result of the atmospheric and soil conditions, at least on some of the islands, is such as to preserve the dead bodies. I have observed on the Chinca Islands the exhumed bodies of men who, having died in service on the islands, have been buried in the guano or sand. These bodies, disinterred in time by the removal of more guano, seemed almost perfectly preserved.

Nests of the gallinazos were observed in the islands of Lobos de Afuera and Lobos de Tierra. In December, 1907, three nests of the *aura* were found, one in a cave on the hillside, another under a small overhanging ledge of rock (pl. 53, fig. 3), and a third in a narrow deep cave just above the water line on the beach. In the first case, as the bird flew from the nest it emitted a brownish vomit, which created an unendurable stench. Scarcely any effort seemed to have been made to form a nest. The eggs are slightly yellowish white, spotted and blotched with reddish brown, and little reduced at the smaller end. The measurement of two eggs from one nest were 72 by 50 mm. and 74 by 50 mm., and of two from another nest, 71 by 47 mm. and 72 by 47 mm. These are smaller than the dimensions given by D'Orbigny (83 by 54 mm.). The photograph (pl. 53, fig. 3) shows two young birds with whitish down and blackish bills fairly well concealed against the rock beneath a barely overhanging ledge.

THE CHIROTE.

The small "chirote," *Cinclodes taczanowskii* Berlepsch and Stolzmann, is of particular interest as the only land bird, beside the condor and the buzzard, observed on any of the islands. They were seen only on islands of the south—the Chinchas—and the Isla Vieja at Independencia Bay.

Our camp on the north island of the Chincha group was located on a small crescent-shaped bit of beach between the water and the cliffs, where the chirote was regularly seen flying back and forth from the cliff to the beach. Their nests were not observed, but the time was early winter of the southern hemisphere—June, 1907. In the gonads of a specimen taken the eggs were distinguishable only with a lens. The stomach contained sand and bits of shells of Gastropods and Lamellibranchs.

The lively *Cinclodes* recalls both the Wheatear and Dipper, as it runs with upturned tail from stone to stone, takes short low flights, or hunts for crustaceans, mollusks, and insects in the water, equally happy on the streams of the Andes or the desolate lake sides of Patagonia. The note is a sharp trill, while three eggs are laid on a bed of grass and fur in holes.¹

It is believed that this is the first record of this bird from the Peruvian Islands. *Cinclodes* belongs to the family Furnariidae peculiar to the neotropical region.

THE SEA LIONS IN RELATION TO THE BIRDS.

Two kinds of "lobos" are distinguished on the Peruvian coast—"lobos ordinarios" and "lobos finos," or "lobos de dos pelos" (ordinary "lobos" and fine "lobos" or "lobos" with two coats). This

¹ A. H. Evans, in the Cambridge Natural History.

distinction corresponds to sea lions and fur seals. I did not observe the fur seal, but from the uniformity of local accounts I would assume that it occurs in small numbers as far north as the peninsula of Paracas.

The sea lion, *Otaria jubata*, occurs fairly abundantly along the entire coast. There is scarcely an island of any size without its "loberia" or rookery of sea lions. Naturally, this animal has some relation to the birds. Many persons have charged them with being very destructive of the guano birds. Some years ago the capture of lobos in Peru was permitted and it was found that the value of the hides and oil was sufficient to make the industry profitable. Subsequently this fishery was stopped by governmental prohibition, chiefly because of the extensive use of dynamite, but partly because it was suggested by some persons that the lobos rendered an important and necessary service to the birds in herding the fishes, driving them to the surface, or demoralizing them, and consequently making it easier for the birds to obtain their food. These questions were of particular interest and it was consequently kept in view to note such observations as might bear on them.

To the sea lions has also been ascribed some importance as producers of guano; in fact, the literature of the subject almost invariably attributes Peruvian guano to the "birds and sea lions." Some definite observations were made on this point, and it may not be inappropriate to refer to them briefly and before proceeding to the proper subject of the section, in order to establish more precisely the significance of the birds in relation to the valuable deposits of guano.

THE SEA LION AS A PRODUCER OF GUANO.

It is well known that there have been deposits regarded as lobo guano, deposits which may have been entirely guano of lobos, or a mixture of the guanos of lobos and of birds. That the lobos now produce a very insignificant amount of available guano seems to be the unanimous opinion of those most practically concerned with the guano industry. I have observed a good many hauling grounds of sea lions between Paita and Independencia, but have usually found that the rocks were clean. The resting grounds were, as a rule, on the rocks close to the water, and, as the sea lions floundered and slid over the rocks going into and out of the water, they swept away with them not only their own, but also such guano of birds as may have been in the way. The rocks are thus left smooth and slippery.

Some exceptions must be made. A small island was visited in 1907 off the Punta Lobería, just above Cerro Azul, where there had been a recent deposit of "lobo guano." According to the best information that could be obtained, this island was cleaned of guano

10 years before and was not worked afterwards until the season of 1906. During two years there were removed in all something over 3,000 tons. If this information is correct, this guano was deposited during a period of 10 years, and at the average rate of 300 tons a year. This is on the supposition that the island was really cleaned 10 years before, though it is probable that it was not cleaned then with the same thoroughness with which islands are swept now.

The guano was different in appearance and odor from that of birds, an abundance of hair being especially noticeable. There was an enormous quantity of skeletons and skins of lobos, many of which perhaps had been left on the island when it was last cleaned of guano. Although, except for the hairs and bones, it was largely pure manure (with only 8 per cent of sand), there was scarcely any odor of ammonia. The color was brown to black and somewhat greasy.

Analyses of two samples of guano taken from different places on this island, as made by Mr. H. H. Bunting, chemist of the Peruvian Corporation, are given in the first two columns of the following table:

	(1) "Sea-lion guano," Cerro Azul.	(2) "Sea-lion guano," Cerro Azul.	(3) "Sea-lion guano," Lobos de Afuera.	(4) "Sea-lion guano," Pure sea-lion faeces.
Moisture.....	29.40	23.40	8.32	43.96
Sand.....	8.22	8.05	1.15	.40
(a) Organic matter.....	17.74	18.86	48.43	18.94
(b) Phosphoric acid.....	16.80	19.88	16.89	16.34
Alkali, salts, etc.....	27.84	29.81	25.21	20.36
	100.00	100.00	100.00	100.00
(a) Containing nitrogen.....	2.86	3.21	7.90	2.33
Equal to ammonia.....	3.47	3.89	9.59	2.83
(b) Equal to tricalcic phosphate.....	36.67	43.41	36.87	35.67

The presence of some feathers suggested a degree of participation by birds in forming the deposit, but the low nitrogen value proves that the part of birds was inconsiderable.

Another small island, in the Lobos de Afuera group, contained a deposit of mixed lobo and bird guano, the high proportion of nitrogen indicating a substantial proportion of bird guano. The analysis is given in the third column of the table of analyses.

The latter deposit had been formed in a more humid climate (Lobos Island) than the other (Cerro Azul), so that the guano would naturally have suffered more deterioration; yet the nitrogen content was higher and there was other reason to suspect that birds had contributed to the formation of the deposit. In order to ascertain just what was the nature of the fresh lobo guano unmixed with that of bird, several portions of fresh faeces were taken and mixed to form one sample, which was dried, bottled, and analyzed. The result is shown in the fourth column. The nitrogen figure is even lower than the samples taken from the beds at Cerro Azul, but after allowance

is made for the varying proportions of moisture in the total, it will be found that the proportion of nitrogen to solid matter is almost exactly the same in the pure guano as in the two Cerro Azul samples.

From the most elementary principles of mammalian physiology it is, of course, to be inferred that the nitrates would be absent from the guano on account of being excreted with the urine and in a form subject to loss both by evaporation and seepage. From all observations it is safe to say that the sea lions should not be credited with any significant part in the formation of the guano deposits, both on account of the small amount deposited by them in secure places and because of the low nitrogen value of the guano.

THE SEA LION AS ENEMY AND COMPETITOR OF THE BIRDS.

The suggestion that the sea lions, as great consumers of fish, have caused a serious diminution in the food supply, and consequently in the abundance of birds, may be briefly dismissed. Sea lions are, of course, competitors of the birds in the search for food, but the sea lions and birds have existed together for untold ages, and there is entirely wanting any evidence of suffering on the part of the birds for want of food. On the contrary, I was invariably impressed with the comparatively brief portion of the day occupied by the cormorants and pelicans in the search of food, and the correspondingly considerable proportion of the time which they spend upon the islands. There is every reason to believe that these birds are not nearly up to the maximum number which might exist upon the normal food supply, and the deficiency is without any question attributable to the molestation of the rookeries during the past 60 years.

That the sea lions will destroy birds at times is indisputable. Many persons with long experience on the islands mentioned having seen the sea lions eat the birds or tear them open for the fish contained within. Many of these observations are perhaps made under abnormal circumstances when helpless birds are forced into the water. However, I had the rare opportunity to witness the killing of a pelican by a sea lion, and the incident is worthy of description. It should be mentioned that this was near an abandoned island, so that there was no known unusual circumstance to demoralize the bird.

When first seen the lobo had taken the bird apparently by the legs. He dragged it about a little and then by an arched dive carried his captive completely out of view under the water. After a few seconds they were up again. This action was repeated several times, the lobo evidently endeavoring to get a good hold with his jaws on the belly of the bird, protected by its very thick covering of feathers. At first the pelican made so little struggle that I should have thought it dead, but that the neck was held quite erect. It seemed thoroughly demoralized, but, after the third dive, began to fight the lobo with

its big bill. The defense was quite useless. It was carried below the surface, and when it appeared again its helpless condition and the blood in the water showed that the fight was finished. The lobo was tearing off the meat from the belly and the water about was red. He continued tearing his prey until our boat could arrive and take the mutilated body. This was subsequently photographed. The skin and feathers of the whole lower part of the body, with the meat, some of the bone, and the entrails, had been torn away. As the lobo was still tearing at the alcatraz when it was taken, it is evident that the meat of the bird, and not simply the fish within, was the object of the attack. On another occasion I found floating in the water a bird mutilated in similar fashion. It was evident, however, that these cases were so rare that, so far as the birds were concerned, no serious destructive effect could be charged to the sea lions.

Reference has been made previously to the evident fear of large animals, such as porpoises and sharks, manifested by a tamed pelican.

THE ALLEGED COMMENSAL RELATION OF SEA LIONS AND BIRDS.

It is undoubtedly an advantage to the birds that larger animals demoralize the schools of small fish and keep them at the surface. Yet I was not able to see the same close relation in this way, between useful birds and sea lions, as between birds and bonitoes. Frequently, there have been opportunities to observe a school of anchobetas pursued by bonitoes below and birds above. As one watches such an assembly of fishes and birds appear from the distance on the one side, pass and disappear again on the other, the thousands of small fish breaking the surface as the bonitoes leap among them and the cloud of birds plunging and diving, one is left with little doubt as to the benefit that the guano-producing birds may derive from the bonitoes. In regard to sea lions, porpoises, and sharks, this relation is not so clear. The small birds which pick their food from the surface without necessarily going into the water, such as the terns and sea gulls, may frequently be seen hovering over and following the sea lions for advantage in capturing small fish. There is no doubt as to the benefit they derive, although such fowl are not valued from the economic side. The chief birds, the "guanay" and the pelican, as well as the gannet, take their fish by going into the water, and it is probable that fear of the sea lions and other large animals would deter these forms from dropping into the sea close about such animals. For several minutes I have watched pelicans and gannets circle over a school of anchobetas without a plunge, until I supposed that the birds could not be hungry, for the fish were breaking the surface in a dozen places and were easy of access; then suddenly they began to make their headlong plunges from the air. It is difficult to apply any other explanation for the delay than that a preliminary recon-

noissance is necessary in order to ascertain what other animals are after the fishes. With many opportunities for observation, I observed the large birds feed from schools of fish that I knew to be pursued by lobos only where the school was an immense one, and, therefore, where there could be little to fear from the sea lion.

There is yet another point of view from which some light may be gained. If the lobos are of especial value to the birds we might expect to find some direct relation between birds and lobos in their distribution. Are the birds found in greatest abundance where the lobos are most numerous?

At the islands of Lobos de Tierra there were observed considerable numbers of birds, but not a large number of lobos, although one outlying island, occupied around its base by sea lions, was crowned with a rookery of guanays. At Lobos de Afuera the birds were still more numerous, especially pelicans, but sea lions were comparatively few. Macabi Island was almost without birds, but was surrounded by populous loberias. At Guañape there were a great many gannets, but, at the time of my visit, few other birds. There were considerable numbers of sea lions. In the Bay of Chimbote there were not many birds, but an abundance of lobos. In the Chinchas and Ballestas Islands, the only island which had practically no nesting ground was the middle island of the Chinchas, and this was the island about which were found the greatest number of lobos. San Gallan showed few birds, but some large loberias. In the region of the Bahía de Independencia, with its islands of Vieja and Santa Rosa, sea lions are very abundant, while birds are practically absent. Only the small terrecele was abundant at Santa Rosa, and this is the kind of bird that may derive much help from the lobos, because they barely strike the surface of the water as they take their fish, but they produced little guano.

In almost every case the disappearance of the birds, or their decrease in numbers, is largely due to the way they have been treated by man, although the sea lion may have formed a part of the unfavorable condition. For example, at such a place as the Santa Rosa Islands, it is probable that the sea lions did not accomplish great harm to the birds until the working of the islands began. Immature birds that could fly from the land, but could not rise from the water, into which they had been driven by man, would fall an easy prey to the sea lions. It is very natural that the birds would abandon those points where they were pursued both on land and on the water, sooner than those where their enemies were only on the land.

The conclusions arrived at from all observations were: (1) That the sea lion as a producer of guano was not of sufficient value to require its protection; (2) that, as regards the relation between the sea lions and the birds, the evidence did not indicate that the sea

lions were either of much benefit or of very significant injury; (3) that when the good was balanced against the harm, the difference could not be sufficiently great either way to demand the destruction of the sea lions, on the one hand, or the absolute protection of them, on the other.

The sea lions are, of course, destructive to fishing apparatus and even to fish when in nets or on the hooks. It was recommended to the Government that a limited catch be permitted, the use of dynamite to be prohibited, and the number to be taken in any locality to be restricted, with a view to the preservation of the species and promotion of the industry.

BIRDS OF THE CHINCHA ISLANDS IN THE PAST AND THE PRESENT.

On becoming acquainted with the guano islands on the coast of Peru it seemed to me rather surprising that it should have been supposed and so frequently stated in works of reference that the chief guano-producing bird was the *Sula variegata*, or "piquero." Tschudi, in fact, selected this bird for experiment and found that it produced $3\frac{1}{2}$ to 5 ounces of guano a day. It was assumed at first that Tschudi had been misled by the fact that these birds are exceedingly abundant and by their conspicuousness in the harbors, where their precipitous and graceful plunges must attract the attention of any observer. But how could he have overlooked those long black streaming clouds of "guanays" (*Phalacrocorax bougainvillei*) which lie low over the water for miles?

Stating briefly the conditions as they were in 1906 to 1908, the "guanay" is by far the most important producer of guano, while the pelican is second, and the other birds fall far behind. In June there were 15 acres of guanays on the south island of the Chinchas (latitude 14°), and two months later the extent of the flock was probably well over 20 acres. I saw no other flock, neither of cormorants nor of any other species, to compare to this one, and there were, besides, many smaller aggregations of guanays on various islands. North of Independencia, at least, this was the chief guano-producing bird, except in the north, at the Lobos Islands, where the pelican took first rank. Even at the Lobos de Tierra there was a large flock of guanays. The scarlet-foot cormorant, or so-called "pato de mar" (sea duck), *Phalacrocorax gaimardi*, is one of the most common birds along the coast south at least of Guañape, but, from its habit of nesting on the cliffs and in the caverns, is of no value as a producer. And the same may be said of the less abundant black cormorant, or cuervo de mar, *P. vigua*. The bird next in rank to the pelican is the piquero, *Sula variegata*. The small diving petrel, *Pelecanoides garnoti*, deserves consideration from its abundance in certain localities and from the supposed value of its guano. The penguin, *Sphe-*

niscus humboldtii Meyen, found from Lobos de Afuera southward, is not now sufficiently abundant to count, economically speaking. Other birds, such as the gulls, and terns, are very numerous, but for various reasons they are of quite secondary economic significance.

It will be of interest now to compare the accounts of previous observers. Unfortunately few of the naturalists who have made collections and observations on the Peruvian coast actually made visits to the guano islands and left records of their observations.¹ If we go back to Humboldt, we find his statement (as quoted by Raimondi and others) that the Chincha Islands were occupied by a multitude of birds, especially "ardeas" and "fenicopteros" (herons and flamingoes), a statement which it would indeed be difficult to credit. Since he also states that these birds have not in the course of three centuries, been able to produce more than a thickness of 4 or 5 lines of guano (whereas in fact many times this thickness is deposited in one year), we must believe, either that Humboldt wrote from information received at second-hand, or else, as Raimondi suggests, that the presence of the birds mentioned was a chance observation. In any event we must neglect this account.

¹ The earliest published reference to the guano birds is found in Garcillasso de la Vega, who made no mention of the varieties of birds contributing to the guano deposits. His record is however, of great interest and importance, not only for its historical value, but because of its definite recognition of the significance of contemporary birds as agents in guano production. This native historian possessed, of course, a more accurate knowledge of conditions and a more intimate experience with things concerning Peru than Humboldt, who, though he must be credited with the principal part in directing the attention of the world to the possibilities of the guano deposits, yet seems to have been responsible not only for manifestly incorrect statements regarding the birds, but for establishing for the time being, the erroneous and unfortunate impression that the deposits were of a merely fossil nature and unreplenishable. Had Humboldt given correct information it might earlier have been recognized that it was commercially useful to protect the birds as was done in the time before the conquest. Garcillasso de la Vega's record is of sufficient interest and relevance to be given, as quoted and translated from Raimondi:

"By the seacoast from below Arequipa as far as Tarapaca, which is above 200 leagues, they use no other manure but such as is derived from the marine birds, which live along the entire coast of Peru, large and small, and which go in flocks of a size that is incredible if they are not seen. They breed upon the uninhabited islands which occur along that coast; and so much is the excrement which they leave upon them that this likewise is incredible. The mounds of manure appear from a distance as snowy mountains. In the time of the Inca kings such vigilance in guarding the birds was maintained that, at the time of breeding it was forbidden to anyone to enter on those islands, under penalty of death, in order that they might not disturb nor drive them from their nests. Neither was it permitted to kill them at any time within or without the islands, under like penalty." (Antonio Raimondi: *El Peru*. Vol. 4, p. 489. See also: *The Royal Commentaries of Peru* in two parts: written originally in Spanish by the Inca Garcillasso de la Vega and rendered into English by Sir Paul Rycaut, Kt., London, 1688. Part 1, Book 5, Chapter 3, p. 135.)

It is remarkable that the rulers of Peru in the days before the conquest should not only have realized that the birds must receive protection, but that they should have seen the necessity of adopting for this purpose, such an economic system in the exploitation of deposits as has in recent years been recommended to the Government of Peru. (See the writer's article in *Science*, cited on p. 449 above.) For the Inca goes on to say:

"Every island was by order of the Inca assigned to such and such provinces, and if the island were very large, then two or three of them divided the soilage, the which they laid up in separate heaps, that so one province might not encroach on the proportion allotted to the other; and when they came to make their division to particular persons and neighbors, they then weighed and shared out to every man the quantity he was to receive; and it was felony for any man to take more than what belonged to him, or to rob or steal it from the ground of his neighbor, for in regard that every man had as much as was necessary for his own lands, the taking a greater quantity than what belonged to him, was judged a crime, and a high offence; for that this sort of birds dung was esteemed precious, being the best improvement and manure for land in the world. Howsoever, in other parts of that coast, and in the low countries of Atica, Atiquipa, Villacori, Malla, and Chilca, and other Valleys, they dung their grounds with the heads of a small fish, like our pichards, and with no other soilage." (*Royal Commentaries*, p. 136.)

Tschudi, however, seems to have visited the Chincha Islands (and others) and he mentions several species as important.

Guano is formed of the excrements of different birds, as mews, divers, sheerbeaks, etc.; but the species which I can name with more precision are the following: *Larus modestus* Tschudi [gull]; *Rhincops nigra* Linnaeus [skimmer]; *Plotus anhinga* Linnaeus [snake-bird]; *Pelecanus thuyus* Molina [pelican]; *Phalacrocorax gaimardi* [patillo] and *albigula* [guanay] Tschudi; (*Pelecanus gaimardi* Lesson, *Carbo albigula* Brandt), chiefly the *Sula variegata* (Tschudi), [gannet].¹

I have inserted the common names. As previously indicated, he placed special emphasis upon the gannet.

When a gentleman of many years experience on the islands, speaking to me of the great diminution in number of birds, especially pelicans, during the period of his acquaintance with the islands, added that the "guanays," however, were by no means so abundant in the earlier years, it seemed that the discrepancy between old accounts and actually existing conditions, as regards this species, might be due to local or regional movements of the birds. This inference is borne out by Tschudi's explicit statement in another work² that he encountered the guanay more often on the south coast in the region of Arica and Islay (17° and 18° S.). Paz Soldan,³ writing in 1862 (and apparently following Raimondi) does not single out the cormorant for special mention in his account of the Chincha Islands (p. 44); but in treating of the guano of the southern province of Tarapaca he refers particularly to "the birds that produce it, which they call in Quichua *Huanay*" (p. 521, translated).

Raimondi's account, however, seems to offer a better basis for comparison.⁴ He spent 40 days on the Chincha Islands (evidently in 1855) and his notes should be correct for the time. He lists two cormorants (*bougainvillei* and *gaimardi*) with this remark, which is not true now as applied to the former species (translated):

It appears that the Carbos do not contribute much to the formation of guano, since they live almost always on the more rugged places and in the clefts of the rocks, so that the guano they produce generally falls into the water.⁵

We must believe that the guanays were not occupying the Chincha Islands "in mass" in the times of Tschudi's or Raimondi's visits

¹ J. J. von Tschudi. Travels in Peru during the years 1838-1842. Translation by Thomasina Ross, New York, 1852, p. 168. [The guano industry had no importance in Tschudi's day and it does not appear that Tschudi was correctly informed as to the general conditions, though his observations are doubtless correct for certain points visited.]

² Tschudi, J. J. von. Untersuchungen über die Fauna Peruana. 2 vols. St. Gallen, 1844-46. Section "Ornithologie" in second volume, p. 314.

³ Paz Soldan, D. D. Mateo. Geographia del Peru, obra postuma del D. D. Mateo Paz Soldan, corregida y aumentada por su hermano, Mariano Felipe Paz Soldan. 2 volumes, Paris, 1862, 1863.

⁴ Raimondi, A. Mémoire sur le guano des isles de Chincha et les oiseaux qui le produisent. Comp. rend, Acad. Sci., vol. 42. Paris, 1856.

Raimondi, Antonio. "Apuntes sobre el huano y sobre las aves que lo producen." The paper is undated, as published posthumously in the fourth volume (pp. 457-496) of Raimondi's "El Peru," Lima, 1902 (cited on p. 469 above). It appears to have been originally published in 1874, in El Siglo, ano 1, Nos. 1 and 2, and to be based upon the article in the Compte Rendus, previously cited.

⁵ Raimondi, A. 1902 [1874] El Peru, p. 494.

(1842 and 1855). It is possible but hardly probable that they were on other islands of the immediate region at that time. It is to be remarked that the south islands, which seems best suited to the guanay, was unoccupied at that time by guano workers, and was, according to his statement, the chief home of the penguin (which is more easily disturbed by intruders than the guanays), and that it was besides abundantly populated with diving petrels.

Raimondi's remarks regarding the relative abundance of the several species of birds (except as regards the guanay) may be approximately true to-day. *Plotus* and *Rhyncops*, he says, are very rare. Of *resident* birds ("sedentarias") those which most abounded in the order, in which he named them, were the pelican, the gannet, the gull (*L. modestus*) the penguin, and the diving petrel. It is evident, then, that these islands were simply preempted by other species, then vastly more abundant than now; accordingly, the guanays found more living room at other places, especially, by Tschudi's account, in regions much further south. In later years the species formerly dominant have, in consequence of the more extensive industrial activities on the islands, either diminished in numbers or been driven to other nesting grounds, making way for the guanay—a species which is less sensitive to disturbance.

In regard to the guanay, then, it must be concluded either that it has greatly increased in numbers during the past half a century, or else that it has appeared in regions where it was not formerly a regular habitant. The latter is by far the more probable conclusion, for its ancient common name would indicate that it was recognized as the paramount guano bird of prehistoric times, as it is of the present.

The Sulas, Raimondi stated expressly,¹ produce more guano than the pelicans or the cormorants, because, besides inhabiting the rugged places they cover at times a part of the island ("cubren a veces la parte de las islas"). This statement with its qualifying phrase, "at times," scarcely confirms Tschudi, but in the earlier paper² he says "they keep themselves in the interior of the island." As these birds in their present abundance find adequate nesting ground upon the cliffs and comparatively abrupt slopes, they now rarely overflow onto the more level ground. This applies not only to the Chinchas, but to the entire coast as observed. We are perhaps justified in assuming that the Sulas have diminished considerably in numbers since the period of Tschudi's or that of Raimondi's observations.

The penguin, *Spheniscus*, in Raimondi's time, had quite abandoned the north island, and was rarely found on the middle (these two were being worked), but were in "great abundance" on the south island. These helpless penguins are now in vastly reduced numbers, for, while they are frequently in evidence about the islands of the Chincha

¹ Raimondi, A. El Peru, 1902 (1874).

² Raimondi, A. Le huano des isles de Chincha, 1856.

region and in the Bay of Independencia, 60 is the largest number I have seen in one group.

Another striking observation of Raimondi's is in regard to the diving petrel or "potoyunco" (*Pelecanoides garnoti*), and is expressed as follows (translated):

Finally, the *Puffinurias*, in my opinion are the birds which produce the greater quantity of guano; as much for the quantity which each deposits, as for the incalculable number which inhabit these islands. It appears also that these birds are continually diminishing in the north island, being found only toward the southeast part of the island; while on the middle and southern islands they are found in all parts. Like the preceding (*Spheniscus humboldtii*) they live under the guano at a depth of 1 or 2 feet, having thus with their galleries mined the whole southern part of the north island; so that one may not make a step in this part without sinking to the knees.¹

It is surprising that Raimondi should ascribe to the penguin, as well as to the diving petrel, the habit of burrowing under the guano.

He goes on then to describe how the Chinese peons destroy great quantities of these birds, taking them from their subterranean nests and preserving the meat by drying in the sun. This unfortunate night work still continues, being followed not only by the laborers on the island, but by the fishermen of San Andres near Pisco, who make a practice of salting the birds to eat or to sell subsequently at home.

The potoyuncos are now found on all islands of this region, but there are not enough left on the islands of the Chincha and Ballestas groups for anyone to attach especial importance to the amount of their guano production. Their chosen home, at the time of my observations, was the lofty San Gallan, whose long hillsides are in many places undermined by the crowded burrows of these little birds, from the hard saline crust at the base of its sweeping slopes up to the grassy summits of the peaks that are lost to view in the clouds. Even here, much as one may be impressed by the comparative abundance of these interesting birds, or by the persistence with which they will ascend into the very clouds in the vain endeavor to find a safe retreat for their tunnels, one can not ascribe to them a relatively great economic value. The diving petrels, too, we must conclude, have been greatly reduced in numbers.

Finally, although there is little in the statements of the writers mentioned to show that the pelican was ever much more abundant than now, I had too much testimony from various sources, and too much independent evidence, to doubt for a moment, not only that this bird was much reduced in numbers, but that it was tending toward elimination as a commercially significant guano producer.

As bearing upon the changes of aspect in the bird life of the island reference should be made to the phenomenal disappearance of some

¹ Raimondi, A. El Peru, 1902 (1874), p. 495.

of the principal species of birds in 1911, as recorded by Forbes ¹ and tentatively attributed to a possible seismic disturbance of unusual severity. From his further remarks it may be inferred that the birds returned in full numbers before his observations on the coast were concluded.

I would not conclude these remarks without adding the hopeful note that under the vigorous protection which Peru must sooner or later extend to its sea birds in defense of its guano and agricultural industries, an opportunity will be given to all the useful species to regain as best they can, the condition of abundance determined by the conditions of their natural environment.

¹ See citation of Forbes papers on p. 487 and p. 490, above.

APPENDIX.

LATITUDES OF PLACES MENTIONED IN THE TEXT.

Among the points visited by the writer those mentioned in this paper, with their approximate latitudes indicated, are named in the following list, and the locations of the principal places are shown on the accompanying sketch map of the coast of Peru:¹

- 3° 30' S. Tumbes.
 5 Paíta.
 6 30 Lobos de Tierra Island, and islets.
 6 56 Eten.
 6 57 Lobos de Afuera Islands, East, and West, and islets.
 7 24 Pacasmayo.
 7 50 Macabi Island.
 8 36 Guañape Islands, North and South.
 9 08 Chimbote.
 11 48 Pescadores Island.
 12 Callao.
 12 San Lorenzo Island.
 12 20 Pachacamac Island.
 12 30 Chilca.
 12° 48' S. Asia Island.
 13 Punta Loberia and islet.
 13 Cerro Azul.
 13 40 Pisco.
 13 39 Chincha Islands, North, Middle, and South, with islets.
 13 40 Blanca Island.
 13 44 Ballestas Islands, North, Middle, and South, with islets.
 13 50 San Gallan Island.
 13 50 Paracas Peninsula.
 13 59 Zarate Island.
 14 16 Vieja Island, Bay of Independencia.
 14 16 Santa Rosas Islands, Bay of Independencia.
 17 Mollendo.

¹ The map is reproduced by courtesy of the Geographical Review published by the American Geographic Society, New York City.

